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A TREATISE ON

HYGIENE AND PUBLIC HEALTH

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A TREATISE ON

HYGIENE AND PUBLIC HEALTH

With Special Reference to the Tropics

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PREFACE TO THE EIGHTH EDITION

A NEW edition of this manual being called for, opportunity has been taken once again to revise the whole text. While minor alterations have been made in almost every page, many portions have been rewritten and a large amount of new material has been introduced to bring the book up-to-date according to the modern conceptions of preventive medicine.

The introductory chapter has been mostly rewritten and an effort made to present to the student the present position of preventive medicine in all its bearings so that a greater interest may be aroused in the student in this increasingly important aspect of his profession. The monographs on Genetics and Eugenics have been considerably enlarged and a new article on Epidemiology has been added in the chapter on Preventable Diseases, where the various ideas on the causation of epidemic diseases, from the time of Hippocrates to the present day, have been discussed. In addition, special articles on Yellow Fever, Relapsing Fever, Typhus Fever, Weil's Disease, Mumps, Cerebrospinal Fever and Venereal Diseases have been added. Short descriptions of certain additional animal parasites, viz. Gastrodiscoides hominis, Clonorchis sinensis, Paragonimus ringeri, and Hymenolepsis nana have also been given.

Several new diagrams have been added to illustrate the text and some of the old ones have been replaced by new and more modern ones. To prevent the book from getting too bulky I have thought it advisable to enlarge the size of the page so as to keep it within a reasonable size.

In the preparation of this edition I have received valuable help and assistance from many of my friends, and I am specially indebted to Lt.-Colonel G Covell, M.D., I.M.S., for once again revising the monographs on Mosquitoes and Malaria ; to Dr. E. Muir, M.D., F.R.C.S.E., in charge of Leprosy Research, Calcutta School of Tropical Medicine, for revising the article on Leprosy ; to Dr. Keshava Pai, O.B.E., M.D., in charge of the Tuberculosis Hospital, Madras, for his article on Tuberculosis ; and to Dr. K.V. Krishnan, D.Sc., M.B , M.R.C.P.E., D.B., of the All-India Institute of Hygiene, Calcutta, for contributing the article on Venereal Diseases, to all of whom I take this opportunity of expressing my thanks and appreciation.

I am again under a deep debt of gratitude to Lt.-Colonel A.D. Stewart, C.I.E., I.M.S., for his unfailing courtesy and cordial co-operation ; for much valuable advice, and for the trouble he has taken to revise the proofs of the whole book.

While all that is good in the book I owe to the kindly help of my friends just mentioned, I accept responsibility for all the defects which may appear in the work.

I trust the book will continue to receive the appreciation of the profession which has been so long accorded to it, and that it will maintain its position as a text book for students and as a work of reference for public health workers in the tropics.

CALCUTTA
June, 1935

B. N. GHOSH

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INTRODUCTORY

PREVENTIVE MEDICINE AND PUBLIC HEALTH ADMINISTRATION

THE science and art of medicine has three sides: curative medicine, preventive medicine, and constructive or conservative medicine, known as hygiene. All these three aspects should be regarded as an integral part of medicine, and to separate curative medicine from preventive medicine takes away the unity of the science. Curative medicine however holds an important place both amongst medical men and the laity. Our ultimate aim being prevention of disease, the importance of preventive medicine is being more appreciated with the advance of our knowledge of the causation and prevention of diseases. Sir George Newman has rightly observed "It is not the event of death which we can escape but the incidence of avoidable invalidity and premature death. It is the enlargement of life and the increase of human capacity, physical and mental, which we seek to ensure." The idea that public health is solely a matter for sanitarians, municipalities or the health departments of the Government is fast disappearing, and it is more and more being realised that not only medical men but every citizen are directly interested and intimately concerned in the preservation of the health and welfare not only of themselves but of the community as a whole.

Health is not merely absence of disease. The conception of health envisages the full development of physical, mental and spiritual powers with which an individual is endowed. In order to understand how disease is prevented it is necessary to have a clear conception of what disease is and how it is carried. In the earliest endeavours to explain and combat disease, disturbances of health were attributed to supernatural agencies, to deities and demons, to obscure occult influences exercised by the stars, fairies, witches and the like; and the restoration of health was sought by means of prayers and sacrifices, conjuration and exorcism, charms and spells. With the progress of our knowledge in biology, bacteriology and other allied branches of the science our conception of disease has broadened; and since life is governed by biological laws, it is only by investigation and knowledge of life's laws that we can hope to combat or avert the phenomena resulting from the interplay

of certain universal biological processes which we call disease. Modern research has shown that most of the diseases which are preventable are caused by some specific organisms carried by different agencies. These may be air, water, or some other intermediaries, such as insects. The study of the life history of these pathogenic organisms has revealed the role which the various animal hosts play in harbouring, developing and transmitting them, and we have to take into account their life and activity in the animal as well as the human host. Since the nature and propagation of different diseases differ from one another, measures appropriate for their prevention must necessarily differ. Thus our knowledge regarding the spread of malaria will require measures quite different from those of cholera or plague. Inasmuch as impure air and water, pollution of soil, errors in diet, uncleanliness of the house and its surroundings, bad disposal of excretal matter, etc., play important parts in the spread of disease, it is necessary that these environmental factors should be carefully studied which are so essential for the health and welfare of the community. On the other hand the individual himself as an important unit of the community requires to be educated to enable him to appreciate the value of sanitation not only for his own health but also for the community in general.

Death has been described as the soul changing its old and worn out body for a new one much in the same way that man changes his old garment. Whether we accept this view of life and death is a different matter, but it gives sufficient evidence to contemplate that death is a natural phenomenon which should come in the fullness of years and is not necessarily an evil. Dissatisfaction with life is the outcome of individual or collective disappointment—a disappointment to which disease has been responsible to a large extent. National fatalism is not the monopoly of the East. It has been bred everywhere on disappointment and prevalence of epidemic diseases. The ideal of preventive medicine is to help all men to live their natural span of biological existence by preventing premature death from disease which is so distressingly common in this country.

The scope of preventive medicine is daily increasing, and the old maxim "prevention is better than cure" has been appreciated by the surgeon, and the development of aseptic surgery is an instance in point. Other practical applications of the knowledge in preventive medicine are the protection of the child before birth by taking such precautions as will enable it to be born healthy ; protection of the mother from the harmful effects of pregnancy and childbearing, and the protection of the child after birth by establishing maternity and child welfare centres; limitation of birth for the health of the mother; preservation of racial progress and

prevention of racial degeneration by following the principles of eugenics; taking such precautions as will prevent accidents or other occupational diseases; production of artificial immunity for protection from diseases like small-pox, diphtheria, enteric fever, cholera, etc.; and adoption of such measures as will protect the community as a whole from water-borne and other communicable diseases. There are however certain obstacles to the universal application of sanitary measures. They are ignorance, indifference, conservatism and the prejudice against interference with personal liberty and comfort. These can only be got over by education, health propaganda, co-operation and mutual understanding between the public, the health workers and medical men, and by studying the effects of public health activities in other countries. It will be interesting therefore to study the progress and development of the public health administration and activities in other countries before we proceed with the consideration of the different aspects of the subject in detail.

At present the general medical practitioner in India has very little direct relationship with public health activities, but it is different in other countries. In England, for instance, the general practitioner has been brought very closely into relationship with many aspects of public health administration and health movements. But there is every possibility of a rapid development of public health activities in India and in this the ordinary practitioner will likely be involved. It is therefore desirable and essential that the medical man in India should have some acquaintance with the growth and development of public health administration in other countries so that he may be able to appreciate how these have grown and developed and in what directions they are now progressing. In this way he will take a keener interest both in helping to frame and to develop public health activities in India.

It is strange that before 1830 there was practically no real interest taken by any state with regard to the public health. The growth of state relationship in public health is therefore of very recent origin. It will be useful to consider shortly the history of the development of public health administration in England, for it was in this country that the connection between the state and the people in public health started. Afterwards we shall describe briefly the position in India in the past and the present, and the probable future lines of development.

Up to the end of the 18th century England was practically a rural country as India is at present. About this time the invention of the steam engine and the application of steam power to machinery (specially the weaving machine) led to an industrial revolution as it is called. The weaving industry, which had been confined to hand looms in the

rural districts, became transferred to large machine driven factories. This resulted in the emigration of rural population to large rapidly growing towns which up to that time had been very few. These grew rapidly without any preconceived system of water supply, disposal of excretal matter, or of housing. The consequence was that they were exceedingly unhealthy, and infectious diseases rapidly spread amongst them and conditions of living were almost indescribably bad. The workers were housed in crowded rooms without regard for comfort, ventilation or decency. There was no proper arrangement for water supply provided by the town, no system of disposal of refuse or excretal matter, conditions of working were terrible, young children, women and old men worked for twelve to thirteen hours a day for a mere pittance. The result was that cholera, typhus and other infectious diseases flourished. Death-rates were high and the average length of life extremely short. The attention of the then Secretary of the Poor Law Board, Sir Edwin Chadwick was drawn to these conditions. He investigated and reported on the sanitary conditions of the labouring classes in England, and so vivid was his description that this report immediately attracted the attention of the Government authorities. Chadwick was convinced that these diseases were the outcome of the environment in which these people lived. His suggestions were simple. Rectify these defects, he said, provide good houses, good water supplies, good systems of excretal disposal, regulate conditions of labour and ensure good conditions for working, protect the labouring classes from the too selfish exploitation of the employer and things would be remedied. His opinion was strengthened by the religious movement of John Wesley who preached for the first time the responsibility of one class of the community to another. Chadwick also suggested the machinery by which these suggestions could be carried out. He said that in the Central Government there should be a department concerned with public health which should directly supervise and if necessary compel local governing bodies to rectify matters in their area. These local bodies or local sanitary authorities, as they are called, would be directly responsible for carrying out improvements in their particular areas and for dealing with infectious diseases. These broad principles were accepted by the Government as the result of the Royal Commission which was held. The outcome was the passing of the Public Health Act of 1848. This Act created a Central Board of Health for five years to deal with local self governing bodies and to give them advice. In 1853 the Act had been applied to 182 places, but the activities of the Central Board aroused great antagonism amongst the upper classes who felt their vested interests were being affected. In 1854 the Central Board

was modified and its activity was curtailed in 1858. The Act was then passed only for one year. In 1855 Sir John Simon was appointed Medical Officer to the Board and continued as such until 1869. From 1858 and till his retirement Sir John Simon's reports on public health, cholera, tuberculosis, housing and industrial diseases, etc., greatly impressed both parliament and people, and it was due to his illuminating reports and tactful dealings with local bodies that the opposition to the activities of the Central Board was gradually broken down. In 1869 Sir John Simon realised that the time was opportune to review the whole question again. A Royal Commission was appointed to report on "The operation of sanitary law on the authorities both Central and Local by which sanitary law was administered." The report of this Commission is now a classic and it was largely drawn up by Sir John Simon. Its recommendations were (1) there should be a consideration of sanitary laws which should be made *uniform*, *universal* and *imperative* throughout the kingdom; (2) the constitution of a Central authority to administer Sanitary and Poor Law and in which would be centralised all the various medical departments under the Government; (3) that in each area there should be one and one only local sanitary authority for carrying out its duties; (4) that each local authority must appoint one medical officer of health and one sanitary inspector; and (5) each district should be inspected by medical and engineering experts belonging to the central authority. Sir John Simon thus envisaged a department in the Central Government which should deal exclusively with all matters of public health, in other words a Ministry of Health presided over by member of the Government (the Minister of Health) who would be responsible to the elected legislature on the one hand and to the Government on the other. This ideal however, did not appear at once. In 1871 a Local Government Board was formed. This was composed of the principal members of the cabinet and presided over by a president, and had a secretary, who together as a matter of fact did all the work. Its medical staff had no direct access to the local authorities which they were inspecting and advising, but had to deal with them through the secretary and the president. Local authorities in the same way could not deal with the medical advisers of the Board directly. In the year 1875 was passed a Public Health Act which created one local authority in every sanitary area and embodied in its various sections the principles which had been enunciated by Sir John Simon. This Act is the foundation of English Public Health and the principles enunciated in it are still fundamentally true. This Act at once led to tremendous improvement in the environmental conditions in the towns of England. Pure water supplies were provided,

disposal of excretal matter was immensely improved and rendered less dangerous, defects in houses and factories and food supplies were remedied. Despite the defects in the Local Government Board excellent work was carried out by the medical officers of the Board. These defects were not remedied until 1919 when a Ministry of Health was formed and the Minister of Health took over all medical matters except medical education and research. The Chief Medical Officer of the Ministry of Health has direct access to the Minister and the medical staff deal directly with local bodies in matters of health. This has led to great improvement and smooth working of public health administration in England. In 1929 an important Local Government Act was passed which re-arranged the local authorities and redistributed their duties; no great change of principle was however involved.

It will be seen that Chadwick's original idea was that man's environment determined his health. This is undoubtedly true, but it was not until after the discovery of the bacterial causation of disease by Pasteur and others that it was realised that there was another aspect of the question. Attention now had to be directed to man himself as it was realised that he himself was the reservoir of his own diseases. This aspect which may be termed the "individual aspect" of public health as opposed to the "environmental aspect" is now the dominant note of public health activity in England. The State realises now that its duties do not cease in simply providing good environment and in dealing with outbreaks of infectious diseases. It is now considered to be the duty of the state to see that every individual of the community is looked after from the very moment of his birth, or even before, throughout his whole life, and that he should get every opportunity to keep good health. This may be termed a socialistic outlook, and so it is in the best sense. In England the state provides the machinery to look after an individual from the time before he is born to his old age. The pregnant woman for instance may go to an ante-natal clinic provided by the state, and get advice about herself and her unborn infant. In this way many diseases are avoided and healthy infants are born instead of diseased. If she is a working woman she is not allowed by the Factories Act to work for four weeks after her confinement, and during this period she gets a benefit of thirty shillings from the National Insurance Act. At her confinement she is attended by a midwife who must be trained and certified, and who should call a doctor in case of trouble. The birth of a child must be notified at once to the health visitor to visit the woman. The health visitor gives the woman advice about the upbringing and care of the child, and the necessity of breast feeding; and explains to the mother the benefit of attending child welfare clinics,

which exist in every district and town. These clinics are supported from Government funds. When the child goes to school he comes at once under the care of the School Medical Service. Three complete examinations of the child are made during his school career and careful watch on his health is kept both by the teacher and the school medical doctor, and by public health nurses. When the child after leaving school enters a workshop or factory, he comes under the operation of the National Insurance Act. When in ill-health, the worker is entitled to free medical attendance. The various Factories Acts ensure that conditions of work are kept satisfactory and hours of labour are carefully regulated. Women and children are forbidden to engage in dangerous trades and compensation is given for accidents and diseases which are the result of work. Special laws have been passed for the free treatment and prevention of tuberculosis and of venereal diseases. Persons afflicted with the latter are entitled to free diagnosis and treatment. When a man reaches the age of 65, if he has not been able to provide himself with an income, he may be granted an old age pension. This illustrates some of the interests which the State now devotes to the "individual," as well as to the environment.

Public Health Administration in India

The first real development in public health administration in India took place in 1859 when the administration of India was taken over from the East India Company by the Crown. The heavy mortality of the European troops in India arrested the attention of the parliament in England. A Royal Commission was sent to enquire into the reason of the heavy mortality amongst the military and civil population of India. In 1861 the mortality of the European army was 69 per 1000, in the Indian army 20 per 1000. In civil jails the death-rate was between 84 and 120 per 1000. The corresponding figures from 1910 to 1914 are:—

Mortality 4.36 per 1000 for European army.
Do 4.39 ,, ,, for Indian army.
Do 20 to 50 per thousand in civil jails.

The Royal Commission reported in 1863 and suggested the appointment of "Sanitary Commissions" of five persons in Bengal, Bombay and Madras. The Sanitary Commissions in Madras and Bengal then advised the immediate formation of Public Health Services. These proposals were laid aside for many years. The Madras Commission, however, made considerable progress in reducing mortality. In 1869 the Commissions were practically abolished, only the medical officer remaining, who was then styled "The Sanitary Commissioner." From this time onwards there have been considerable arguments regarding the position and relationship

of the Sanitary Commissioners to the local head of the medical department. Sometimes it was thought that the Sanitary Commissioner should be a senior officer and independent, sometimes that he should be a junior officer under the head of the medical department. In 1904, however, it was agreed that the Sanitary Commissioner should be directly under Government and not under the Surgeon-General and should communicate his views directly to Government and not through any other medical official. As we have seen from the previous history in England, this is as it should be. There was perhaps little real progress in sanitary administration until the arrival of plague in 1896 in Bombay. Its ravages aroused every one in the country and in Government to a realisation of the defects in the sanitary administration and the necessity for some reconstruction. As a result of the Plague Commission, a separate Public Health Commissioner was appointed with the Government of India in addition to the head of the Medical Department. His duties were mainly to advise the Government of India on sanitary matters and to direct research. At this time the Government of India had practically full control over provincial governments in public health matters. In 1912 a new department was created in the Government of India to deal with education and health. Extra staff was deputed to each province both for the extension of general and provincial sanitary staffs, and large grants were given to the local governments to assist in the development of this advance in policy. Twelve extra Deputy Sanitary Commissioners were granted and thirtyfive first and second class Health Officers for municipalities. The Government of India declared that while the general direction of a policy of public health must remain with the Central Government detailed control and executive action should be left to Local Governments. This was the position prior to the Reforms Act of 1919.

The Provincial Governments were given advice and grants of money to increase the staff, both central and local, and were encouraged to advance along the same lines. In Bengal, Health Officers were appointed in districts and health officers and sanitary inspectors in the municipalities. The Health Officers of districts and of municipalities are not Government servants but the servants of the local bodies who employ them, though the Government pays part of their salaries. In other provinces District Health Officers are provincialised and are government servants, and are lent to district boards and municipalities and may be transferred from place to place as Government think fit. The English system is similar to that in Bengal and is of course the most logical. It is however open to argument as to which system suits best Indian

interests in the present juncture. In 1919 the Reforms Act entirely changed these relationships. Public Health became a transferred provincial subject under the control of an elected Minister. The Government of India gave up all right of interference or direction in provincial public health affairs and reserved to itself only a few matters, such as quarantine and pilgrim traffic and international health relationships outside India. Each province has therefore been left to develop its own policy of public health and neither the Government of India nor any other province has the right to interfere in any way. There has been very little consultation between provinces since 1919, and there is no doubt that the loss of co-ordinating policy is probably detrimental to the development of public health in India as a whole. The Simon Commission has made a note on this point, and in Volume I has recommended that whatever form of system of Government should eventuate within the next few years, there should be a strong Central Board of Health which would co-ordinate public health matters throughout the whole of India. The report makes no specific recommendation as to the form and composition that this Board should take, but there is no doubt that their proposal is a wise one.

The present system of Government of India approaches in form the Federal System of the United States of America, the Union of South Africa, the Commonwealth of Australia, and the Dominion of Canada. The study of the systems of public health administration in these countries is interesting, as it would appear probable that the form the Government of India is bound to take will at least resemble a federal system. The duties of the Federal Department of Public Health of U. S. A. are (1) the protection of United States from the introduction of disease from without and prevention of interstate spread, the suppression of epidemics, the investigation of disease, and the dissemination of health information; (2) it also supervises the manufacture of biological products and co-operates generally with the State and Local Health Departments in assisting and giving advice in health matters. The accomplishments of the Federal Public Health Service are many and various. It is an admirable example of Governmental usefulness. The Federal Health Departments of Canada, Australia and Africa practically carry out the same duties. It will appear that the present is a suitable time for the serious study of this important question when great changes are likely to take place in the constitution of India.

A word may be said about provincial health systems of administration. At present the portfolio of Public Health is in the hands of one of the elected ministers who is a member of Government. Public Health is a part of the department

of Local Self Government for which there is a permanent Secretary, usually a member of the I. C. S. The medical department is administered by the Surgeon-General. In the Public Health Department, the Director of Public Health has a staff of Assistant Directors in charge of various sections. Matters of health are dealt with by the Minister who deals through the Secretary with the Director of Public Health. We have seen in England how clearly the relationship between the Ministry of Health and the Local Sanitary Authorities are defined. In Indian provinces relationships and duties of the Public Health Department on the one hand and of Local Sanitary Authorities on the other are indefinite. Local Sanitary Authorities are often under the impression that every thing should be done by Government agency, while Government, whatever may be their opinion, have not the power by law to insist on Local Sanitary Authorities carrying out specific sanitary measures or improvements. Most provinces are quite aware of this fact but have not yet considered the time opportune to handle the matter so definitely as was done in England in 1875. There are various reasons. In the first place most of the population, in fact over 90 per cent., is rural, and one knows by experience in England that it is more difficult to make advances in sanitation in rural areas than in towns where people congregate together and common water supplies and excretal disposal systems can be installed. Most district boards and municipalities have not too much money to spend and there is little use in passing too much mandatory or compulsory legislation which could not be carried out.

The activities of public health administration and some of its achievements have been indicated, and it is hoped that not only medical men but the general public will take a keener interest in the improvement of health. As we have seen, many of the great developments of public health policy in England were not introduced by medical men, and public health is a far greater subject for statesmanship than many other political questions which now loom large in the public eye.

International Health Relationships of India

With the growth of communication by sea and air the risk of importing infectious diseases from abroad and of transferring such diseases to other countries especially to Europe and America have become more acute. Indeed with the speeding up of communications the world has become much smaller from the point of view of inter-communication. Diseases like plague, small-pox and cholera were freely disseminated by trade ships. Within recent years the first outbreak of plague in Bombay was introduced through trade

routes from China. It was therefore recognised that some concerted action by the interested nations was desirable and it has been the custom of different Governments interested to frame rules by mutual agreement to control the different communicable diseases, and from 1851 onwards International Sanitary Congresses were held, and since 1907 International Sanitary Conventions have been agreed to by most countries. The Convention has made certain rules which have a world significance for the control of diseases like cholera, small-pox, plague, yellow fever, typhus, etc. In 1926 the Convention met at Paris and delegated to the Office International d'Hygiene Publique the duties of supervision of the international measures of quarantine under the direction of its Permanent Committee. After the war the League of Nations was formed which again established a Health Committee, an advisory body without any executive authority, but which works in close association with the Office of the International d'Hygiene Publique. The Health Section of the League is now an important body and is helping solution of the many important problems with its different Committees and Commissions. At Singapore it has an Eastern Bureau to collect information of infectious diseases from different Eastern ports which is weekly broadcasted to enable every country, specially all the ships on the Eastern waters, to be acquainted of the existence of infectious diseases in the ports or ships.

Within recent years facilities of air travel have made it possible for persons to land uninfected countries while incubating infections contracted in an infected country. There is also the possibility of carrying infected mosquitoes to places where such infections are unknown. To combat such inventualities an International Sanitary Convention for Aerial Navigation has recently been signed by several countries situated on aerial high roads. The Permanent Committee of the Paris Office in October 1933 decided to appoint a Standing Commission to be known as Aerial Navigation Quarantine Commission, whose duties will be to examine the various questions which have arisen and will from time to time arise, in connection with aerial navigation and public health, with the interpretation of the Convention generally, and its application to local circumstances. The Standing Commission will work in close liaison with the International Commission for Aerial Navigation (established by the International Convention of the 12th October 1919) which controls civil aviation generally. The reports of the Standing Commission of the Paris Office after having been approved by the Permanent Committee, will be communicated to Governments at the same time as those of the Standing Quarantine Commission.

CHAPTER I

WATER

WATER, though not strictly speaking a food, is absolutely necessary for the maintenance of life, both animal and vegetable. It is mainly used as a solvent and diluent in the human economy, but for these purposes only a small quantity would suffice. With the progress of civilisation, however, the demand for water has considerably increased and it is now required for :—

1. Domestic use for the following purposes :—
   (*a*) As food for building up the tissues of the body, maintaining the fluidity of the blood, and helping in the excretion of waste matters.
   (*b*) Cooking and washing.
   (*c*) Personal cleanliness.
2. Municipal and trade purposes :—
   (*a*) Road watering.
   (*b*) Drain flushing in the water-carriage system of sewage disposal.
3. Washing stables and carriages, and for animals.

Quantity of Water Required.—The amount of water required daily for domestic use varies greatly, and depends mainly on the habits of the people and the particular sanitary arrangements of the place. From a sanitary standpoint one should encourage a free use of water and at the same time discourage unnecessary waste. For modern requirements of health and cleanliness a sufficient amount of water is of the utmost value. The quantity of water required has been variously estimated by different observers. Parkes and Kenwood give the following as the daily allowance for all purposes :—

		Gallons per head
Household	Fluids as drink	0.35
	Cooking	0.65
	Ablution	8.00
	Utensil and house washing . .	3.00
	Laundry washing	3.00
	Water-closets	5.00
Trade and manufacturing	... ...	5.00
Municipal	Watering streets, public baths, fountains, flushing sewers, and extinguishing fires ...	5.00
	TOTAL ...	30.00

In hospitals 40 to 50 gallons per head must be supplied daily. In Calcutta the daily allowance of filtered water

per head is 45.7 gallons ; unfiltered water being used for flushing water-closets, drains, etc. Other Indian cities allot less. In small municipal towns about five gallons per head is the minimum quantity alloted for drinking and domestic use. Of the British towns Glasgow supplies 58 gallons, London 37, Manchester 36, and Edinburgh 50 gallons per head.

A horse requires about 15 gallons and a cow 12 gallons per day. This amount, however, varies with the season and the size of the animal.

A most important factor in the supply of pure water in a large city is the prevention of waste. Although a certain amount of wastage is unavoidable, the greater part of it is preventable. The principal causes of this waste are (*a*) faulty mains and service pipes ; (*b*) leakage from stop cocks and other defective fittings in the house ; (*c*) storing water in reservoirs, etc., for daily use and throwing away the same every day ; and (*d*) allowing the water to run at night or when not required. In order to regulate the supply and consumption of filtered water and to prevent unnecessary waste, water meters are sometimes used. But the restriction makes people less clean in their habits, and encourages the use of unfiltered water, which is dangerous in tropical countries being too often polluted with specific organisms.

Sources of Water

All water is primarily derived from the *ocean*, and in tropical regions the evaporation of water into the air is very great, and it has been estimated that about 700 gallons are evaporated every minute from each square mile of ocean surface. Winds blowing over a large expanse of water become laden with moisture, and as soon as the cooling effect is produced by a lower temperature, it returns to the earth as *rain, snow, dew, mist or hail.* It follows, therefore, that the *condensed water* from the air is the ultimate source of all our natural water-supply. But the following are the common direct sources :—

Rain Water.—Rain is the purest water which occurs in nature. On reaching the surface of the earth part of it is evaporated, part flows to form rivers, etc., and helps to feed tanks and lakes, while the rest percolates into the soil until it reaches an impervious layer where it either remains in the porous strata overlying the impervious layer, or may travel laterally till it reaches the surface as springs. Its purity however does not remain, as it receives impurities from the air or from the surface upon which it falls. It absorbs gases and takes up dirt from the lower regions of the atmosphere. Thus it may contain nitrogen, oxygen and carbonic acid ; and near the sea common salt, and

sulphate ; and in towns ammonia, acids, dust, soot, suspended matter, and even microbes.

In many countries rain water is the only source of water-supply, and therefore it requires to be collected and stored in underground tanks or reservoirs with proper precautions for drinking purposes. When collected from the surface of the ground the area should be especially constructed for the purpose and rendered impervious by cementing. When collected from the roofs of houses the first portion is usually dirty, as it generally contains animal matters from the excreta of birds, street dust, eggs of insects, soot, etc., and should therefore be thrown away. By fixing "Roberts' Rain Water Separator" on the rain water pipe, the latter portion of rain water can be collected, as it allows the first portion to run to waste.

Although rain water may receive impurities before it reaches the earth, these are of little importance since they are not pathogenic like cholera and enteric germs. But after it falls on the earth it is for all practical purposes a surface water with all its dangers, unless of course it is collected and stored with proper precautions, when it can be used for drinking purposes. Rain water is very *soft* owing to the absence of salts of lime and magnesia, and is therefore suitable for cooking, washing, and bathing purposes. It is insipid and not very pleasant to take unless aerated. In the tropics *Aedes (Stegomyia) œgypti* breeds by preference in artificial cisterns holding rain water.

The amount of rain is measured by a *rain gauge* (*q. v.*). and is expressed in inches of depth. A rainfall of 1 inch in depth corresponds to about 4.673 gallons on a square yard, or 22,617 gallons (101 tons) on each acre.

In estimating the annual yield of water from rainfall and the yield at any particular time, we must know the maximum annual rainfall, the minimum, the average, and the period of the year when it falls, and the length of the rainless season.

When rain water reaches the ground and joins on its way a river or other collection of water it is then known as *surface water*. In fact water from rivers, lakes, tanks, etc., is surface water. The classification however is arbitrary as there is no marked line of demarcation between rain, surface and ground water, as rain water soon becomes surface water, and surface water when it passes into the ground becomes subsoil water, which again reappears in streams, lakes, etc.

Ground Water

Springs.—These are formed when for some reason the ground water is made to overflow upon the surface. Rain water falling upon the surface of the earth gradually

passes down through the soil to varying depths until it reaches the impervious layer where it accumulates as *subsoil or ground water.* Beneath the pervious rock there is always at a greater or lesser depth a stratum of an impervious character which holds up the water. The surface of this stratum is sloping, and the water runs along this until the impervious stratum reaches the surface of the soil, where it issues as a spring. Springs therefore may be regarded as natural wells outcropping where the geological formation is favourable.

Springs are of the following kinds :—

(a) Surface Springs originate from percolation of water through beds of sand or gravel overlying an impervious stratum, and in fact are outlets of limited collections of subsoil water. They are often intermittent, ceasing to flow in summer (April to September) and starting again in autumn (October) after percolation has commenced.

(b) Main Springs are deep-seated springs having no surface outlet, but issue through a crack or fissure in the soil. They usually give continuous supply with certain variations during the different periods of the year.

(c) Intermittent Springs are usually found in valleys bounded by rivers and high hills. The flow depends on the amount of rain and subsoil water.

(d) Hot or Thermal Springs.—Where volcanic eruptions have ceased evidence of high internal temperature is often to be found in springs which continue to maintain their heat even for centuries. Thermal springs are not confined to volcanic districts alone; they may arise even in places hundreds of miles away from any active volcanic vent. As instances of this kind may be mentioned the *Sitakoond Spring* in India, and the hot springs of Bath and Buxton in England.

Springs afford good sources of water-supply for small communities. The water-supply of Kurseong is from a spring and throughout the dry weather the water supply of Darjeeling is from the springs. Spring water, as a rule, is pure, and since no mechanical means are necessary to draw the water it is less liable to contamination. The greater the degree of percolation the water undergoes, the more perfect is the filtration and more clear and bright does it become. It is generally cool and palatable. But the character of the water in different springs differs. It is highly charged with carbonic acid gas obtained from the ground air; aided by this and increased pressure it dissolves out lime and various mineral salts contained in the soil through which it passes, consequently it is hard and less suited for washing and cooking, although it may be valuable for medicinal purposes.

Springs are also liable to contamination at the point of

issue; therefore if the water is used for drinking purposes they require to be protected. Thus a leaky cesspool above a spring may contaminate the water directly. Stables, privies, etc., should be located at a considerable distance. The spring should be protected by a concrete wall which should extend well into the ground and thus protect pollution from surface washings. The surface water which would otherwise pollute spring water should be carried away by a specially constructed drain.

Yield of a Spring.—This is estimated by taking a vessel of known capacity and observing how long it takes the spring to fill it up. The output of the spring in one hour can thus be determined, and as the allowance per head is known the total quantity required is calculated.

Wells.—A well is an artificial pit or hole sunk into the earth to reach the water level into which the subsoil water percolates. Wells form an important source of water-supply in Indian villages. Formerly they were in use in certain towns also, but have now been abolished in favour of a public water-supply which has been introduced in most towns. There are three kinds of wells:—

(*a*) Shallow or surface wells.
(*b*) Deep wells.
(*c*) Artesian wells.

(*a*) *Shallow Wells.*—Wells which tap the subsoil water only are known as *Shallow Wells.* The water of all shallow wells is therefore often contaminated. Moreover if the soil be of a porous nature the impurities will percolate into the well, and although the soil is able to remove a certain amount of these at the beginning, eventually the filtering power is lost and the sewage gets into the well and the water becomes dangerously polluted. Before a well is dug its location should be carefully considered, taking into account the surface configuration, the nature of the soil, and any sources of pollution within at least fifty feet.

By properly constructing the wells the possibility of contamination may be minimised. There should be a parapet wall of about two feet above the level of the ground to prevent surface washings from entering the well. Unless the well is covered, the upper part of this wall should be made sloping from above downwards and outwards to prevent vessels, etc., from being placed on it. All wells for public use should be protected by a cover, and the water drawn by means of a hand pump, which should be fixed either on the platform or on the parapet wall. (*See* Fig. 1.)

Norton's Abyssinian Tube Wells are used when a temporary supply is wanted. These are really shallow wells formed by driving iron tubes or pipes generally $1\frac{1}{2}$ to 2 inches in diameter into the soil, and are usually 20 ft. to 25 ft. deep. To construct one a hole is made in the soil about 4 ft. to 5 ft.

p, and the first part of the tube which has a perforated
el point at its lower end hammered into the ground by a
oden maul. Successive lengths of tubes are driven into the
, one length being screwed on to the other. When the
soil water is reached a pump is fixed and the first portion
water is drawn out till clear water is available.

These wells are more suitable where the distance of the
ter from the surface of the ground is not more than a few
t. They can be bored in gravel, chalk, and other water-
ring strata, but the sandy bed of an old river is an ideal
ce.

The top of these wells also requires to be protected in the
ne way as described under shallow wells, to prevent
luted water from gaining entrance into the water down
sides of the pipe. As the water is drawn by a pump the
ter is free from most of the dangers of the open wells.
ese wells are specially useful in villages, isolated houses
l camps. They are usually overworked beyond their critical
ocity (*see* page 21).

(*b*) *Deep Wells.*—Deep wells are those which pass through
perficial porous bed and the underlying impervious stratum
reach the water-bearing strata. The casing of these wells
ould also be made of some impermeable material as des-
bed under shallow wells and should extend as deeply into
well as possible, or down to the level of the impervious
atum to prevent mixing of subsoil water.

Deep wells as a rule afford a good supply of water on
count of the efficient filtration the water undergoes by
velling a long distance since it fell on the earth. The
ter of these wells is free from organic impurities ; but in-
ganic impurities are sometimes common which render the
ter unfit for domestic purposes. It may also contain an
cess of lime and common salt. They are however exposed
contamination from surface washings and other sources as
the case of surface wells, specially when they are sunk in a
rvious stratum like chalk or sandstone. If the purity of
e water is to be maintained these wells should be construc-
d and protected in the same way as surface wells.

(*c*) *Artesian Wells.*—These are formed when a boring
ps the water in a pervious layer lying between two imper-
ous ones—the pervious layer having its outcrop on the
rface at a much higher level than the point where the hole
made. The water when so tapped will avail itself of this
tificial channel and will rise or even gush out above the
ound. They are so called after the old province of Artois
France where they have been in use for a long time.
eep tube wells are really artesian wells.

Area drained by a Well.—This is usually about four
mes the depth of the Well and may be even more. Roughly,
well drains an area around it which may be regarded as

an inverted cone the apex being represented by the bottom of the well. This drained area is popularly known as the "cone of filtration." If a shallow well be hard pumped the distance drained may exceed the above area. It follows, therefore, that if there be any source of pollution within this area, contamination will inevitably occur. This draining will depend on the nature of the soil and the amount of depression of the water-level due to pumping. Care should therefore be taken to select a site where any such contamination is impossible, and the distance of the well from such polluting source should be 100 to 160 times the difference in the level of the water in the well that might possibly be produced by hard pumping.

Sources of Pollution.—The chief source of pollution of the water in wells is from the surface washings. Under ordinary circumstances the soil has sufficient filtering power to protect the water, except when it is overburdened with organic matter, when the possibility of the soil acting as a filter becomes less. This happens more frequently with shallow wells which are often situated close to open drains, privies and other collections of filth so that pollution may occur by percolation, or by establishing direct connection after a sudden rise of the subsoil water. Cracks and fissures may exist in the soil or subsoil, or there may be rat holes; these will allow impurities to get into the well without passing through the process of biological filtration. Trees often grow at the edge, plants sprout from the lining, and dead leaves fall and rot in the water, while birds build nests in the crevices. Unless fitted with a pump, every user brings his own vessel and rope for drawing water and the rope in the intervals of duty may tether a cow or lie in some dirty corner.

Detection of the source of pollution is often necessary and is of much practical value. This is done by introducing certain chemicals which may be recognised by their taste, colour, smell and other chemical properties into the drains, cesspools or other supposed sources of mischief. Certain dyes, especially *fluorescein*, when dissolved in alcohol and diluted with 5 p.c. solution of ammonia, can be detected by a fluoroscope in dilutions of 1 in 2,000,000. Salts of lithium are also employed. Their presence even in minute quantities may be detected by the aid of a spectroscope. Sometimes cultures of *prodigiosus*, yeasts and other micro-organisms, unless normally present in water under examination, are poured into supposed sources of pollution, and the water examined at different intervals for the presence of these organisms.

A highly contaminated water sometimes becomes clear and deprived of its suspended organic matter during its passage to a shallow well. The appearance of the water

under such conditions becomes deceptive, but nevertheless it retains its dangerous properties.

Examination of Wells.—This is often necessary, and the following points should be noted :—

(*a*) Any source of pollution within 200 to 300 ft. of the well.

(*b*) Whether any adequate or proper coating lines the sides of the well, or whether there are cracks or fissures on the sides.

(*c*) Depth and size of the well. The bigger the well the better is the water.

(*d*) Depth of the water in the well.

(*e*) Nature of the soil in which the well is sunk.

(*f*) Purposes for which the well is used.

(*g*) Average quantity of water daily drawn.

(*h*) Habits of the people using it, *i.e.*, whether people bathe or wash near it.

(*i*) The way in which waste water is disposed of.

(*j*) Whether there has been any recent rain, if so, its protection from surface contamination.

(*k*) The way the water is drawn, whether by pump or by rope and bucket.

The *yield* of water from a well can be determined by pumping out water to a certain level and noting the length of time it requires to regain its original level.

Wells vary greatly in diameter and depth. It is rather difficult to estimate accurately the amount of water in a well, but the following formula gives an approximate idea of the quantity of water in a well in gallons :—

$D^2 \times W \times 5$ = number of gallons of water in a well.

D = diameter of well in feet.

W = depth of water in feet.

Thus to find out the number of gallons of water in a well 6 feet in diameter with 10 feet of water.

$6^2 \times 10 \times 5 = 1{,}800$ gallons.

Requirements of a Good Well.—1. It should always be sunk in a good soil.

2. The site should be high to prevent entrance of flood water.

3. The casing of the well should be made of solid brick work and lined with cement about 1 in. thick, and the water should come only from the bottom. If the well is lined with earthen-ware or stone-ware rings the joints should be made water-tight with cement. The outer surface between the casing and the earth should be thoroughly rammed in with puddled clay to prevent the admission of surface water into the well (*see* Fig. 1).

4. The area round the mouth of the well to about six feet should be made water-tight with reinforced concrete with a cement surface, to form an impervious platform, and

properly drained beyond what is known as the cone of filtration. The platform should be sloping all round with a channelled drain leading to a pucca drain which carries the spilt water to a distance.

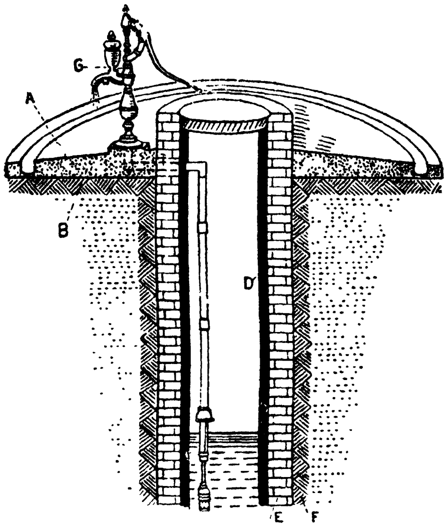

FIG. 1.—A PROPERLY PROTECTED WELL.
A, Channelled drain; B, Platform; D, Cement lining; E, Brickwork; F, Puddled clay; G, Pump.

5. The well should be provided with either a pump, or a special bucket and chain or rope, and no other vessel should be used for drawing up water.

6. All rat holes, hollows, and foul tanks near about should be filled up and adjoining trees cut down.

7. The top of every well should have a suitable covering. To facilitate cleansing climbing hooks should be fixed to the wall during construction.

8. It should be at a considerable distance (250 ft.) from any sewage farm, open drain, trenching ground, or any source of pollution, and at a reasonable distance (80 to 100 ft.) from any human habitation or *bustee*.

Cleansing of Wells.—All wells must be dewatered and thoroughly cleansed at least once a year. This is best done at the close of the hot season when the water is at its lowest level. The water of a well which has neither been used nor cleansed for some time contains a large amount of organic matter, and should therefore be cleansed before using. Cleansing is done by scraping the sides and removing all mud and rubbish which block the pores at the bottom of the well. The sides and the bottom should then be treated with a solution of one part of freshly made slaked lime to four parts of water.

Deep Tube Wells.—Recently deep tube wells have been introduced for the supply of drinking water. They are usually 100 to 500 ft. deep, the depth depending upon the nature of the strata, and ordinarily yield from 1000 to 5000 gallons of water per hour. The yield however varies with the diameter of the tube, and one with $2\frac{1}{2}$ in. diameter yields about 3000 gallons of water every hour. The larger ones are now extensively used for municipal water supply and for irrigation purposes.

The water obtained from these tube wells is as a rule free from bacteria. Thus the water from some of the wells does not show fæcal bacilli in 60 c.c., while others show evidences of fæcal contamination. The water is hard from the presence of calcium carbonate, and contains sodium chloride in variable quantity, traces of iron, and a large amount of CO_2. It contains small amount of oxygen and very little organic matter.

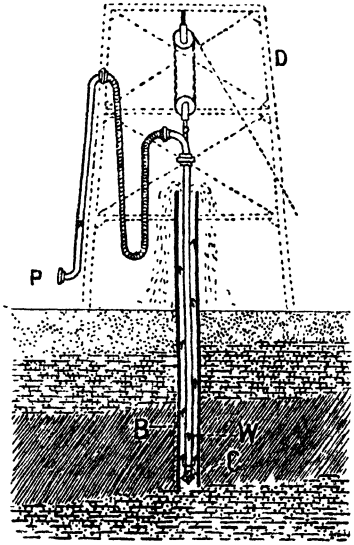

Fig. 2.—Boring of Tube Well D, derrick; C, cutter; W, hollow shaft of cutter through which water is forced; B, tube well; P, connection with pump.

The contamination generally takes place during construction. The essential condition for bacteriological purity is that polluted surface water should not find any access to the strainer or the perforated part of the well. The priming of the pump should be done with clear water. In places where the porous soil extends to great depths contamination can be avoided by sinking the well low enough so that even surface water may be filtered in passing through the deep layers of sand. It is also necessary to sink tube wells in such a manner that no crevices are left along its sides through which surface water may trickle down. To prevent possibility of contamination this space should be well grouted with cement or clay.

These wells require to be carefully managed and one must know the limitation of their working speed as they silt up if the rate of pumping exceeds the critical velocity. The real filtering medium is the sand outside the strainer which should be so designed that the sand grains are not disturbed or sucked in when the water is pumped. When water flows slowly through a bed of sand there is no disturbance, but if the water exceeds a certain velocity it carries sand grains with it. This velocity at which disturbance commences is known as "the critical velocity," and varies according to the fineness of the sand. In designing the strainer for a well of a required output it is of great importance to give proper consideration to "critical velocity." When water is drawn, the level of the water in the well is lowered, and as a consequence thereof the water will tend to flow into it from the surrounding ground. The area within which the level is appreciably lowered is called the "circle or cone of influence."

1. *The closed or driven well.*—In this form the well tube is closed and pointed at one end, and perforated at some distance therefrom. This tube is driven into the ground until it penetrates the water-bearing stratum. When the material penetrated is sand the perforated portion is covered with a wire gauze of fineness depending upon the sand grains. To prevent injuring the gauze and clogging the perforations, the pointed end is usually made larger than the tube, or the gauze may be covered by a perforated jacket. This method of boring is done with shallow tube wells, but where the depth exceeds 75 to 100 ft. the method of sinking is different.

2. *Outercasing well.*—In this form the boring is done by a tube consisting of a steel cutting wedge screwed on to the lower end. This is subsequently replaced by the well proper, the intervening space left after removal of the outer casing should be filled in with cement and sand to prevent surface water flowing down the sides of the tube. The strainer used is generally 15 to 30 ft. long depending upon the depth and width of the well. It is made of brass tubing provided with very narrow slotted holes, made wider in the interior than on the exterior to prevent clogging, and the whole covered with a suitable brass gauze. In the construction of these wells a strong stream of water is run through the boring tube, the water escaping in one or more jets from the top of the pipe, and the loosened earth is carried to the surface by this water. This water has therefore a great sanitary significance, for if a bad water is used it will infect the new tube well water which may take several months to clear. A tube well properly sunk needs no repair, and will give satisfactory service for at least five years.

Surface Water

Upland Surface Water.—This is water collected and stored in hilly districts at the head of rivulets or streamlets. Such a water nearly approaches rain water in purity but its nature depends upon the kind of soil through which it has passed. The water may be collected in natural lakes, as in Loch Katrine for the supply of Glasgow, or in artificially constructed lakes made by building an earth or masonry dam across the outlet of the valley, as for that of the cities of Madras, Bombay, Darjeeling and Liverpool. In Bombay and Madras the lakes are liable to contamination, and the water is therefore subjected to purification before being distributed; whereas in Darjeeling the catchment area is well protected, no human habitation being allowed in the area. Unless the catchment area is guarded the water may contain dissolved organic impurities derived from sewage and decayed vegetable matter. If the hills are covered with peat the water may be brownish or yellowish, but this is harmless

unless in excess when it may give rise to diarrhœa. It can however be purified by running the water through a bed of fine sharp sand. Upland surface waters if collected from a catchment area adequately guarded and well stored are the safest, and being soft are the most economical public water-supply and need no further purification. When the rock contains soluble mineral matters the water will dissolve these. Thus at Salem some surface waters contain salts of magnesia, while at Coimbatore and other places in Southern India the water contains calcium carbonate from lime-stone rocks, nitre, or common salt.

Tanks or Ponds.—Tanks are good sources of water-supply if free from pollution, and are perhaps the only sources of water in most villages. In Bengal tanks are excavated, but in Central India and Madras they are made by putting a dam across the valley. They are commonly

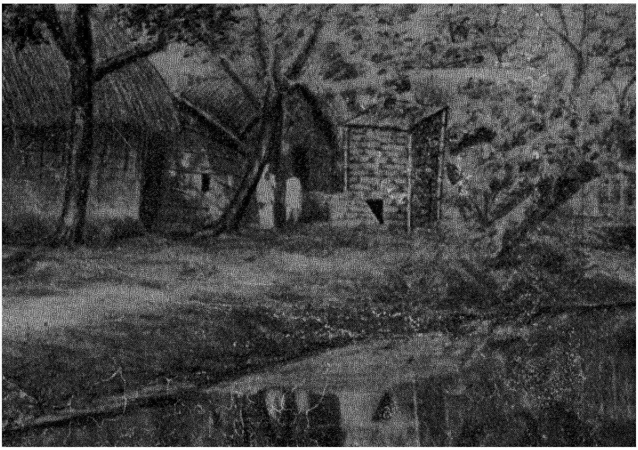

Fig. 3.—Showing Pollution of Tank Water
Note an insanitary privy close to it.

polluted by being used for washing and bathing purposes, by the passage of excrement direct into the water, and by rotten leaves and other impurities. Cattle and domestic animals are often bathed and washed in the tanks; and surface drains are allowed to empty into most of them. In order therefore that tanks may be free from pollution, proper precautions should be taken to prevent contamination.

When tanks are used for drinking purposes the following points should be attended to:—

(*a*) They should be excavated in a good soil having

good surroundings: "made soil" and loose sandy soil having filthy ponds and cesspits in the vicinity should be avoided.

(*b*) They should be deep, tolerably large (about one acre) and of a regular shape.

(*c*) The banks should be properly sloped and covered with grass. The surrounding area should have a low embankment, so that no water can enter the tank except the direct rainfall over the conserved area supplemented by subsoil water from the bottom.

(*d*) They should be *fenced* in or enclosed by railings. Trees should be planted at a fair distance to keep away dust.

(*e*) No bathing or washing of clothes or utensils should be permitted, nor should there be any steps or *ghats*.

(*f*) Arrangements for drawing water from a platform or jetty should be made and no one should have direct access into the water. An ideal arrangement would be to employ a special man with a separate bucket, or to fix a hand-pump.

(*g*) They should always have fish, especially of the smaller variety, which by feeding on mosquito larvæ and other organic impurities help to keep the water pure.

(*h*) Weeds should be removed as soon as they have grown, and the tank emptied and re-excavated whenever the water deteriorates in quality.

Unless the precautions given above can be strictly observed, tank water should not be used for drinking purposes. Owing to sunlight and heat tanks in India have great power of natural purification, and a properly protected tank in Bengal is a very good source of pure water, showing no B. coli in 10 c.c.

Tank water deteriorates in the hot weather from putrefactive changes and improves during the rains by dilution with rain water. In course of time tanks become stocked with water plants, and the annual decay of the plants gradually forms a layer of very offensive mud at the bottom. Certain filamentous green weeds, having the same specific gravity as water, float in layers of several feet in depth and when they die, sink and give off H_2S.

Rivers and Streams.—River water is a mixture of surface and spring water, and usually contains the impurities to be found in both of them. In India, as in most other countries, both rivers and streams furnish the chief sources of water-supply. The river water is fairly pure and unpolluted at its source, but during its course it becomes more or less polluted, as most rivers and streams form the natural sewers of the regions they drain. Where the flow of water in a river is enormous compared with the volume of polluting matter entering, and the water is impounded in reservoirs for subsidence, and the clarified water is finally

subjected to most careful filtration, a good potable water may be obtained. Water from large streams if properly looked after is a good source of supply for towns. Towns, as a rule, draw their water-supply from a river above the spot where the sewage of the town is discharged. But large rivers are able to get rid of a moderate amount of sewage pollution by sedimentation, and by the combined agencies of oxidation, vegetation, and bacterial action.

The composition of river water varies much according to the part of the river whence it is taken. As a rule river water is softer than ground water, but contains a large amount of organic matter. Corpses are often thrown in without burning, and the bodies are torn to pieces by carrion birds, leaving the contents of the stomach and intestines to mingle with the water, while the people wash, drink the water and carry away jars full of it for home consumption. The analysis of Ganges water below Cawnpur showed that 18 miles below the city sewage was still found in the water.

Streams and rivers in their course through cultivated areas, towns and villages often take up impurities derived from sewage and industrial effluents, particularly near the banks, and therefore such water should not be used for drinking purposes without proper purification. In India most of the places for pilgrimage are situated on the banks of rivers and the popular custom of bathing in the river by hundreds makes the water positively dangerous for drinking purposes.

Water for drinking purposes should therefore be collected a few feet from the shore. This may be done by means of a small boat tied to a post or anchored, or by having a sort of a jetty-like arrangement, or by means of a pipe attached to a hand-pump.

Collection, Storage and Delivery of Water

Collection of Water.—The question of supplying pure water to towns requires careful consideration. Where filtration is used on a large scale, the water is generally derived from a river or a stream and collected into large reservoirs or settling tanks. It is a matter of practical importance that the supply should not be derived from any source within the municipal area. Shallow wells and tanks should not be used, as they are mostly polluted; even deep wells are liable to pollution. Springs, deep wells, upland surface water, natural lakes and rivers are the usual sources of supply for waters needed in towns for most purposes. The source available for the supply should depend upon local conditions, bearing in mind that the water should not only be free from pollution but should be soft. Hard water is neither suitable for domestic use nor economical for manufacturing purposes.

Whatever may be the source, the catchment area, the

drainage area and the settling tanks should be protected from any possibility of contamination.

By sinking a number of deep wells or tube wells in a water-bearing stratum away from the town, in an unpolluted soil, good drinking water may be supplied by pumping the water directly into service pipes, or through the medium of storage tanks. Provided the wells are protected from pollution, this method of supply is quite satisfactory and has been utilised in many towns.

Storage of Water.—It is generally necessary to store water, but the methods vary with the source. In upland surface schemes storage is usually made by impounding the water. By this method large artificial lakes are formed which should hold enough water to supply a town for some time. The size of such reservoirs depends on the area of the land and the number of the population requiring the water. Large towns are often divided into districts, each of which has a service reservoir. This system has an advantage: in case of disorder or waste in one district other districts do not suffer in consequence thereof.

Storage is one of the best means of purification, and when done in natural lakes it is cheap, but when done in artificial reservoirs, as in London, it becomes rather expensive, depending largely upon the value of land. The capacity of storage reservoirs should be such as will hold at least a week's supply.

Distribution of Water.—Filtered water is usually delivered by means of iron pipes laid underground. To avoid erosion, particularly when the water is soft, these are coated either with Angus Smith solution, which consists in dipping the pipe in a receptacle containing a mixture of gas-oil and tar heated to about 400° F. In the Barff's process the pipes at white heat are treated with superheated steam for several hours when a film of magnetic oxide of iron is formed. In Calcutta distribution is carried on by steel pipes $\frac{3}{4}$-in. thick and coated with a special asphalt preparation and having a diameter of 5 ft. to 6 ft.

In the distribution of water it is essential that not only the poorest and the least sanitary parts of a town be well supplied, but that there must be a proper water-supply to dairies and cattle-sheds; else the vessels used for milk will be washed in any collection of water available, very often in water highly contaminated by cattle or washings from cattle-sheds. In the outskirts of a city not provided with filtered water, or in the bustees, it would be convenient to supply filtered water to these localities by special water carts, or by sinking a few deep tube wells properly protected and fitted with pumps.

For many of the purposes for which water is used it is not necessary that the water should be absolutely pure.

Where the demand is great, as in large cities like Calcutta, and owing to a deficiency in the amount of pure water available, there is a *dual* system of supply—the impure or unfiltered water for flushing sewers and water-closets, watering roads, extinguishing fires, and for manufacturing or trade purposes ; and the pure water for drinking, bathing and cooking purposes only. With this dual supply the amount of pure water required is less. In villages this double supply is often met with. The well yields water for cooking and drinking purposes, whereas a neighbouring stream, tank or pond furnishes water for washing, bathing, etc. There can be little objection to such a procedure in villages ; in towns a dual supply necessarily involves a second system of mains and supply pipes, and there is the possibility of unfiltered water being used for drinking purposes, and may thus be a factor in spreading water-borne diseases.

Water-supply may be either *intermittent* or *constant.* In many towns for the sake of economy the supply of water is intermittent. There are however certain objections to this system, for instance (1) in the intervals during which the mains and service pipes remain empty, foul air and polluting matter from sewage-charged soil or drains may be sucked in through imperfect joints or decaying pipes ; (2) larger house cisterns have to be provided for the storage of water, which is often wasted ; (3) as the whole day's supply has to be furnished in a few hours, larger mains are necessary ; and (4) in cases of fire water may not always be available.

Decentralised Storage System.—The distribution of water in most towns is generally what is known as "centralised," that is there is a central reservoir from which mains lead to different parts of the town. Stand pipes are erected on the streets in direct connection with the mains and submains, and house connections are also made directly with mains and submains. The advantages of this system are simplicity, comparative cheapness, and ease in design and control ; its disadvantages are that while in areas near the central reservoir pressure and supply are satisfactory, areas distant from the central reservoir and particularly terminal areas receive water at a very low pressure and in much less quantity. The comparatively high pressure and full flow in the near areas result in great deal of waste both from private and public taps.

Mr. Griffin of the Bengal Public Health Department has devised a "decentralised" storage system to counteract these disadvantages, *i.e.*, to provide an uniformly distributed supply equal in amount and pressure all over the town, and to avoid unnecessary waste. The storage is thus decentralised, *i.e.*, the necessary storage for equalisation of demand is scattered over the town in a number of tanks by the road side and in tanks on the roofs of the houses. In order to

give a constant pressure for supply to the roofs and street tanks, the town is divided into several zones, and the pressure is controlled in each zone centre by a "reducing valve." The distributing pipes of each zone therefore always contain water at a definite constant pressure. The connections from the zone pipes to the roof tanks and street tanks, are regulated by means of check pipes, which consist of small copper tubes fixed inside the galvanised iron pipes. The number of public tanks and taps are estimated on the needs of the number of people in the zone, and their location arranged to suit the requirements of density of population. Each tank is fitted with a ball valve which prevents overflowing, and outside is affixed an "indicator" showing the amount of water in the tank. The amount of water delivered to each tank is calculated on the daily allowance permissible per head of the neighbouring population likely to take water from that tank. House connections are given from a "zone" main and passed through a check pipe which will deliver the alloted amount to the house owner per diem.

The advantages claimed for this system are that it confers equality of distribution and amount over the whole town and reduces waste. When a group of house-holders know that their supply tank will deliver only a certain amount of water, and that if the water is needlessly wasted by any one of them they will themselves be the sufferers, they will see that no unnecessary waste occurs.

Impurities of Water

The terms *pure* and *impure* are often used to indicate the character of water. An absolutely pure water is not available in nature, since water always contains gaseous and solid matters in solution and dead and living particulate matters in suspension, received from the air or soil or from both. All natural waters therefore are more or less impure. In the sanitary sense pure water means water which does not contain any substance likely to endanger the health of its consumers. Impure water need not necessarily be injurious to health. Water contaminated with sewage matter may often be used, even for long periods, without any apparent ill effects, but there is always the risk of such a water becoming infected with specific organisms of water-borne diseases, *e.g.*, of typhoid fever, cholera, etc.; hence the use of such water is attended with a certain amount of risk, and it does not therefore come under the definition of pure water. In fact it is impure and unsafe.

Impurities in water may be due to the following causes:—

(*a*) *Dissolved impurities.*—These may be either *gases*, like excess of carbonic acid, oxygen, or sulphuretted hydrogen; or *salts*, *e.g.*, chlorides, calcium and magnesium sulphate,

which make the water hard; or iron, lead and organic matter from soil and other sources.

(*b*) *Suspended impurities.*—These may be *inorganic*, like sand, silt, mud; and *organic*, derived from vegetable and animal matter, bacteria, and ova of worms.

These impurities gain entrance from different sources. The water of rivers, tanks, wells and springs become polluted and impure either from suspended or dissolved impurities. Even rain water becomes impure as it falls on the surface of the earth.

The sources of impurities may be classified as follows:—

(*a*) *Substances received at the source.*—The character of the water depends upon the geological structures through which it has travelled. Thus chalk wells produce hard water from the presence of calcium, and water from the neighbourhood of graveyards contains organic impurities. Water from wells in towns or densely populated places often contains calcium, sodium, nitrites, nitrates, sulphates, phosphates, etc.

Both tank and well water may become contaminated by soakage and surface washings. Very often slop water from village houses is conveyed to the nearest stream or tank.

(*b*) *Impurities derived during transit from source to reservoirs.*—Open conduits like rivers, canals, etc., are liable to be polluted by sewage, house and waste water, manufacturing refuse, etc. Purification, however, goes on during its flow by means of subsidence, by the action of normal water bacteria on pathogenic micro-organisms, and by the presence of aquatic plants. (*See* Natural Purification of Water).

(*c*) *Impurities from storage.*—When water is obtained from a tank or well, or in a town where the supply is intermittent, it is necessary to store water for drinking purposes; but the method of doing so is important, for however carefully the water may be stored it often deteriorates, and by losing its sparkling character gradually becomes flat and insipid.

In this country water is ordinarily stored in *ghurras* or metal vessels, wooden tubs, and masonry tanks (*choubachhas*), etc. When kept in metal vessels and protected by a cover, the water, although it partly loses its aerated character remains pure. *Sarais* and other earthenware vessels keep the water cool and sparkling. These receptacles are often kept under staircases, on landing floors, and in other insanitary places where accidental contamination from dust, dirt, cockroaches, etc., is liable to occur. Under the name of "catadyn" process a purifying vessel has been introduced. It has a coating of colloidal silver which will purify polluted water in two to three hours by contact. (*See* page 39).

(*d*) *Impurities of distribution.*—Where the supply is intermittent and the pipes are occasionally left empty, sewage and impure air may be drawn into the empty pipes through leaky joints and cracks. It is therefore necessary

to lay the water mains at a distance from gas pipes, drains or sewers, and on a solid basis, so as to prevent any cracks occurring from subsidence.

In many places water is distributed by special water carriers (*Bhistees*) who use leather bags or *mushuks* for carrying water. Since it is not possible to keep these bags clean, the water cannot remain pure. Moreover, these men live in bustees under the most unhygienic conditions, and the *mushuk* is kept in places where all sorts of contamination is possible. Unfortunately this sort of transport of water by the agency of *Bhistees* is still prevalent.

Effects of Impurities of Water

Contaminated water may be often used for a lengthened period without giving rise to any appreciable effect on the consumers, and it is probable that in many instances their systems become habituated to its use. For, not infrequently, persons who are accustomed to use pure water, suffer from some trouble when they drink polluted water. But impurity to a certain extent is practically inevitable and is neither disagreeable to the taste nor injurious to the health. An absolutely pure water is insipid and perhaps unwholesome. A good water is not one which is chemically pure. Transparent, colourless, odourless, tasteless water with no suspended matter or excess of total solids, but with sufficient dissolved air, is all that is wanted.

Certain diseases like cholera, typhoid fever, dysentery, etc., having their primary seat in the alimentary canal are carried through infected water used for drinking purposes. Water is occasionally responsible for carrying animal parasites, amœbæ and worms. It may cause derangement of metabolism resulting in such conditions as goitre. But the greatest danger in water is from pollution from human sources. As many diseases affect man alone, water may be a vehicle in carrying specific germs, therefore every effort should be made to avoid human pollution. Since water is used raw, unlike foods which are cooked, it is one of the most common sources of infection.

I. **Effects of Vegetable Impurities.**—Putrid or decaying vegetable matters may give rise to diarrhœa and intestinal troubles and other severe symptoms, in persons unused to it.

II. **Effects of Mineral Impurities.**—Suspended mineral matters or an excessive quantity of magnesium sulphate or chloride may cause irritation of the bowel and set up *diarrhœa*. Brackish water drawn from wells near the sea often gives rise to symptoms of dyspepsia.

Plumbism.—This results from prolonged use of water containing lead. Since lead is never found in any natural water its presence must be due either to the use of lead pipe or to storing water in lead cisterns. It is therefore necessary

hat the conditions under which water acts on lead should be learly understood. The amount of lead which can be taken vithout producing any untoward effects on the system is not lefinitely known. It is possible that individual susceptibility 'aries, but the use of water containing $\frac{1}{100}$ gr. of lead per ;allon in the water-supply of Yorkshire and Lancashire towns ;ave rise to marked and widespread symptoms of lead poisonng (Hammer and Hutt). The accepted standard is that a otable water should not contain more than $\frac{1}{20}$th gr. of lead er gallon. Broadly speaking hard waters unless contaminaed with organic acid have, as a rule, very little action on ead, while soft water dissolves it more or less. Waters conaining CO_2 precipitate basic lead carbonate which is insoluble. f however CO_2 is present in excess the salt is redissolved nd poisoning occurs. Being a cumulative poison very little f it will cause symptoms of poisoning if such water is taken or a long time.

The following kinds of water act on lead:—

1. *Soft waters* by virtue of the dissolved oxygen form xyhydrate of lead which may be dissolved more rapidly by cid water, or the insoluble oxyhydrate of lead may be washed way in fine powder by the flow. Peaty waters are more langerous as by the bacterial action on peat organic acids re formed. Mineral acids cause less plumbo-solvency than eaty acids.

2. *Water containing nitrates or nitrites* in solution, or an xcess of CO_2 exerts a powerful action on lead. Thus polluted hallow well water containing excess of CO_2 tends to dissolve he coating of lead carbonate found in the pipe or vessel.

3. *Upland surface waters* containing humic or ulmic acid.

4. *Neutral distilled water*, and muddy river water.

Waters not acted on by lead:—

1. *Hard water* containing salts of lime and magnesia. These form a coating of insoluble lead salts on the surface f the metal.

2. *Water containing silica*, as silicate of lead is insoluble.

Zinc is occasionally found in water, and water which ontains free chlorine will dissolve a certain amount of zinc rom the surface of galvanised iron. Obstinate *constipation* nay result from the consumption of such water.

Iron is not infrequently found in water and gives rise o *dyspepsia* and *constipation*. Natural waters may contain races of iron. But when water is supplied through iron pipes t is mostly derived from rusting of the inner coating of the ipes. Water containing organic matter may form tubercles f insoluble ferric carbonate or hydrate inside the pipe. Ferruginous water is the medium for the growth of Schizonycete Crenothrix. Chalybeate waters contain iron in the orm of ferrous carbonate.

III. Effects of Animal Impurities.—The principal

diseases of man contracted by drinking infected water are typhoid fever, cholera and dysentery. In all cases the water is infected directly, and therefore tanks and rivers are largely responsible for the outbreaks of epidemics.

Cholera.—Water plays a most important part in the spread of this disease. In India villages on the banks of rivers are especially affected. Outbreaks also occur when the tank or well, which supplies the people with drinking water becomes infected. Epidemics are not uncommon during a pilgrimage or after a bathing festival.

Goitre.—The primary cause according to McCarrison is a micro-organism which in the intestine of man produces a toxin having special effect on the thyroid gland which enlarges. The exact nature of the organism has not yet been identified, but it appears to be present in the soil of goiterous regions, whence they are carried to man through water. Some consider goitre as a deficiency disease caused by the lack of iodine in the water or food. But the fact remains that drinking of certain waters gives rise to this affection.

Typhoid Fever.—This is propagated through water infected by the urine or fæces of patients who are suffering, or have recently suffered from typhoid fever.

Diarrhœa is not infrequently caused by drinking polluted water. Sometimes it may be due to the presence of inorganic impurities, but may also be due to the presence of certain micro-organisms.

Entozoal Diseases.—Diseases due to *Distoma hepaticum, Ascaris lumbricoides*, etc., may be contracted by drinking water containing the eggs, larvæ, or other stages of development in the life cycle of these parasites. *Guinea worm* infection also takes place from drinking water containing infected *cyclops*. (*See* Animal Parasites).

PURIFICATION OF WATER

A public water-supply should be of such a nature as will not require further purification by its consumers. Water derived from carefully protected springs or deep wells needs no such treatment, but in the case of surface water, river water, or water from any source liable to sewage contamination, purification becomes necessary.

Impure water may be purified by either of the following methods :—

- A. Natural
  - I. Storage
  - II. Oxidation and settlement
- B. Artificial
  - I. Physical :
    - *a.* Distillation
    - *b.* Boiling
  - II. Chemical
    - *a.* Precipitation
    - *b.* Germicides
  - III. Filtration :
    - *a.* Slow sand filters
    - *b.* Rapid filters (mechanical)

The primary object of purification is to remove from the

water any traces of pollution that may give rise to disease. It is also desirable to remove suspended matter when the water is turbid, and dissolved mineral matter to render it soft, *i.e.*, make the water suitable for manufacturing as well as for domestic purposes ; a very hard water being undesirable for boiler purposes and for culinary and laundry use.

The principal methods employed for the purification of water on a large scale are (1) storage, (2) filtration, and (3) chemicals. But no method of purification can be considered satisfactory from a sanitary point of view that does not eliminate the germs of water-borne diseases.

A. Natural Purification of Water.—Nature often helps to purify water by various means. In the case of rivers or streams where there is a large volume of water, purification takes place by dilution and sedimentation ; for as soon as any sewage or polluting matter enters a river or a lake it becomes so diluted as to lose all its virulence, and the pathogenic spore-free bacteria soon become attenuated and die in water. Dilution is an important means of purification. Along with dilution, sedimentation of inorganic suspended matter which is favoured by slow moving streams takes place. In this process the bacteria are also carried down to the bottom where they become entangled and die. Delepine has shown that this sedimentation is an important factor in the bacterial purification of water. The aerobic bacteria oxidise to a certain extent the organic materials of the sewage, and the activity of the oxidation depends upon the amount of dissolved oxygen in the water. During the course of this oxidation the nitrogenous substances are mineralised. Aquatic plants also give off oxygen and unless these are destroyed by sewage further oxidation occurs. Moreover, fish and other lower forms of animal and vegetable life which exist in large numbers in certain waters help the purification by feeding on the organic impurities. Besides these factors, sun-light by virtue of the heat and ultra-violet rays exerts its germicidal influence on all surface waters. Of yet greater importance is the evidence of destructive changes accompanied by the loss of virulence which certain organisms particularly those of an "intestinal type" undergo in river and stream waters. These organisms are *B. coli. B. enteritidis sporogenes.* etc. Water is not the natural habitat of pathogenic bacteria as of cholera and typhoid fever. In the struggle for existence they have to fight against the saprophytic bacteria present in water, and being divorced from their natural habitat—the intestine of man—rapidly die out. Storage and reservation therefore are valuable natural purifiers of water.

B. Artificial Purification of Water :—

I. Physical Methods or Sterilisation of Water by Heat. —There are two ways of doing this :—

(*a*) *Distillation.*—By this method water is rendered pure

in a chemical sense. But from a practical and economical point of view it has several objections. For instance, it is not practicable to do this on a large scale. Moreover, distilled water has a flat taste, suggestive of scorched organic matter, and acts on metals. It is used on board ships and should be aerated to improve its taste. In Aden and in some towns on the Red Sea coast the water is distilled as the well water is brackish and rain very scarce.

(*b*) *Boiling.*—By this means certain micro-organisms are destroyed, the temporary hardness of water is removed by the precipitation of calcium salts, ammonia and sulphuretted hydrogen gases are given off. Boiling makes the water very flat and insipid, and it should therefore be aerated before drinking.

II. Purification by Chemical and other Agents:—

(*a*) *Use of Precipitants.*—By these a precipitate is formed which entangles and carries down suspended matters and micro-organisms. After the addition of the coagulant the water may be treated as follows: (*i*) it may be allowed to stand until the precipitate is complete and the water is quite clear; (*ii*) may be passed after a short sedimentation through a mechanical or pressure filter; (*iii*) may be allowed to settle until practically clear and then passed through an ordinary sand filter. The following are the different methods:—

1. *Softening of Water.*—A hard water is that in which calcium and magnesium salts are held in solution in the form of carbonates and sulphates. Hard water is not suitable for washing as the salts form curd with soap instead of lather. It is also unsuitable for cooking and in some industries. Oftentimes owing to the presence of magnesium sulphate it gives rise to gastro-intestinal troubles in persons not accustomed to drinking hard water. When the hardness is due to the presence of carbonates of lime and magnesia kept in solution by carbonic acid, it is known as *temporary*, as the hardness is removed by boiling, which drives away CO_2 gas and thus precipitates the carbonates. $CaH_2(CO_3)_2 + Heat = CaCO_3 + CO_2 + H_2O$. When the hardness is due to the presence of sulphates and chlorides of calcium and magnesium and not dependent on the presence of CO_2 and therefore not removed by boiling, it is called *permanent*. When hard water is used in the water-supply of a city, as for instance part of London supply, where the water is derived from chalk, it is necessary to soften the same. As it is not practicable to boil the water on such a large scale, this is done by adding 1 oz. of CaO per 700 gallons of water for each degree of hardness, as follows:—

$$CaH_2(CO_3)_2 + CaO = 2CaCO_3 + H_2O$$
$$MgH_2(CO_3)_2 + CaO = MgCO_3 + CaCO_3 + H_2O$$

The lime combines with CO_2 holding the chalk in solution and the calcium carbonate is precipitated. This process of

softening water is known as Clark's process. Permanent hardness due to the presence of sulphate of calcium or magnesium is removed by the addition of lime and soda either in the form of hydrate or carbonate, thus:—

$$CaSO_4 + Na_2CO_3 = CaCO_3 + Na_2SO_4$$
$$MgSO_4 + Na_2CO_3 = MgCO_3 + Na_2SO_4$$

Base exchange.—Nowadays zeolite is used for softening water. *Permutit* is artificial zeolite consisting of hydrated silicate of aluminium and alkalies. It has the property of exchanging the sodium base which it contains for other bases. By this process all lime and magnesium salts are removed and salts of sodium carbonate and sulphate are substituted, thus:

$$Na_2Al_2Si_2O_8 + CaSO_4 = CaAl_2Si_2O_8 + Na_2SO_4$$

This method is only suitable for household supplies and manufacturing requirements, but for town supply the cost is more than that of lime and sodium carbonate.

The permutit water softener consists of a closed cylindrical tank the upper part of which contains a chamber where salt solution for regeneration purposes is automatically prepared, a specified quantity of dry salt being placed at fixed intervals. The lower part contains a bed of permutit. The process is one of simple filtration through this bed.

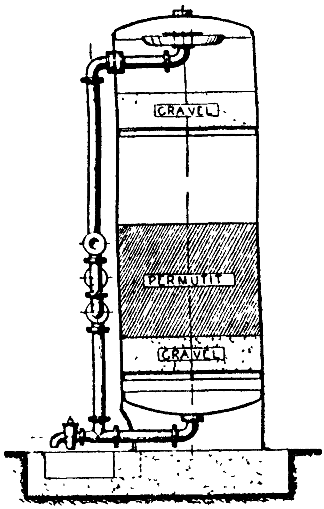

Fig. 4.- Permutit Water Softener

2. *Alum.*—This acts if the water contains calcium carbonate. The quantity of alum used to purify water cannot have any germicidal action, nor any direct chemical action upon the water itself. It forms a flocculent precipitate of aluminium hydrate which entangles suspended impurities and bacteria, and is largely used as a preliminary treatment of rapid filtration. The amount of alum required to clarify water depends upon the pH of the water. Thus more alum is required when the pH reaction of water increases. The total hardness of water also plays an important part in the regulation of the dose of alum. Ordinarily 1 to 4 grains of alum per gallon are required to clarify water, but during the monsoon when the water becomes very muddy, a larger quantity is necessary. But the dose of alum can be reduced by the preliminary addition of some cheap acid, as sulphuric acid. This is done by dissolving alum in acidulated water instead of ordinary water. If the original pH of the water is not high, one should not acidify water too much, as it may affect the taste, or damage

the machinery. The dose of alum and acid should be so regulated that the resultant *p*H may be made such as will not go far from the absolute neutral point which is 7.0. Acid alum therefore is preferable to basic alum. Alumino-ferric (50 p.c. of sulphate of alum and 1 p.c. of sulphate of iron) 1 gr. to the gallon is very widely used nowadays.

The clarifying effect is more marked if 5 grs. of lime is added after the alum. Alum also has the property of destroying water bacteria. Half a grain to a gallon has been shown to reduce 8000 micro-organisms in 1 c.c. of water to 80. Although alum effects such a remarkable reduction of water bacteria, it does not destroy even in greater strengths the typhoid or cholera organisms.

3. *Perchloride of Iron.*—2½ grs. to a gallon will purify water from its suspended organic matter and clay.

4. The fruit of *Strychnos potatorum*, commonly known as "clearing nut" (*Neermali*, vern.) is used in India to clear muddy water. One of these fruits is well rubbed for a minute or so on the inside of the vessel containing the water, which is then left to settle. Within a very short time the impurities fall to the bottom leaving the water clear.

(*b*) *Germicides.*.—The following are the common germicides used to purify water :—

1. *Potassium Permanganate* acts mainly as a germicide by destroying the organic matter on which bacteria thrive. It is specially useful for sterilising relatively small quantities of water, *e.g.*, of wells and cisterns. In proportion of 5 parts per million it removes 98 p. c. of bacteria in 4 to 6 hours. It is rather expensive and is not suitable for sterilising large volumes of water, as of tanks. The best way to employ it is to prepare a solution of a definite strength so that the required amount can be measured. After further dilution this can be poured into the well, etc., and thoroughly mixed up with water. Usually 1 dr. is required for a well 2 feet in diameter and containing about 8 ft. of water. About 1 dr. in 200 gallons of water will be enough to disinfect ordinary water. The amount can also be gauged by the colour test :—A sufficient quantity is added to the water of a well to give it a faintly perceptible pink tinge after the lapse of several hours. It is best to treat water in the evening so that it will be ready for use the following morning. Like most chemical agents its action is not continuous, and it loses its oxygen in oxidising organic matters before killing the bacteria.

2. *Lime.*—Quicklime has long been used for the treatment of polluted water, and Houston has demonstrated that in certain circumstances it is a most effective agent for this purpose. To be effective, good quick-lime or water-slaked lime is necessary. Whiting, air-slaked lime, chalk and carbonate of lime are useless. It is cheap and easily available.

The amount required varies with the character, hardness, etc., of the water to be treated. A fifty feet square tank requires about 14 pounds. It hastens precipitation of iron in water.

3. *Excess of Lime Method.*—In this method part of the water (75 p.c.) is overdosed with lime and then mixed with unlimed water which has been previously rendered safe by storage or other methods, to combine with the excess of lime. The amount of lime required depends on the degree of temporary hardness of the water and the amount of impurity present. Generally enough quicklime is added to combine with free CO_2 and any CO_2 present in the bicarbonate combination, and an excess of lime in the proportion of 1 in 50,000 is subsequently added, for bactericidal action. The water may finally be filtered by rapid filtration to remove calcium carbonate. This method sterilises water in from 5 to 24 hours and removes most bacteria and 50 p.c. of organic matter.

4. *Copper sulphate* is useful for removing algæ and other vegetable growths in tanks. It is used in the proportion of 0.1 to 0.25 per 1,000,000 parts of water. It combines with the bodies of the micro-organisms and settles to the bottom. If the water is afterwards filtered most of the remaining copper is removed. The simplest way to ensure a thorough diffusion of the reagent is to put it in linen bags attached to ropes or strings and then draw them through the water to be treated.

5. *Nesfield's Tablets.*—The action of these tablets depends upon free iodine. A two-grain tablet of iodide-iodate of soda and the same quantity of citric acid is added to four gallons of water, and it is claimed that cholera and enteric organisms are killed in a few minutes.

6. *Bleaching Powder.*—This is made by saturating slaked lime with chlorine at ordinary temperature, and is very efficacious in sterilising drinking water. It is found as a whitish powder or as friable lumps with a feeble odour of chlorine and a disagreeable bitter saline taste. Unlike many other powerful disinfecting agents bleaching powder and solutions of hypochlorites may be used safely for sterilising water for drinking purposes.

Bleaching powder of good quality should not contain less than 35 p.c. of chlorine. Forty pounds of 25 p.c. strength added to a million gallons of water give a proportion of available chlorine equal to one in a million parts. Roughly 30 grs. of bleaching powder is required for 100 gallons. A cubic foot of water contains $6\frac{1}{4}$ gals., and 1 gallon of water weighs 10 lbs. With bleaching powder of lower strengths, proportionately increasing amounts are needed to give the same result. Thus:—

Bleaching powder containing 20 p.c. chlorine would

require 50 lbs. per million gallons ; 15 p.c. would require 67 lbs. ; 10 p.c. 100 lbs., etc.

The student should also remember that 1 oz. of chlorinated lime (25 p. c. strength) added to a well 8 ft. in diameter and containing 5 ft. of water will give approximately one in a million available chlorine.

The amount required to sterilise water effectively varies with the composition of the water. The more organic matter the water contains the more bleaching powder is necessary. A filtered water usually requires not more than 0·25 part of chlorine per 1,000,000 parts of water which is equal to 8 lb. of fresh bleaching powder per 1,000,000 gallons of water. But a water containing iron, peaty matter or a high oxygen absorbing capacity will require several times more of this strength. This method is cheap, reliable, efficient, easily applied and harmless, and when added in proper proportion leaves no undesirable chemical substance in the water. The way it acts on water is complex, but the germicidal effect is due to (*a*) nascent oxygen formed, (*b*) free and liberated chlorine, and (*c*) chloramine formed from the organic matter in the water. It however makes the water a trifle hard, but chlorinated soda has a tendency to make it soft.

Chlorine must act for four hours, and all evidences of chlorine must disappear before the water is allowed for consumption. To disinfect a tank bleaching powder proportionate to the size is first placed in bags which are then attached to ropes and pulled backwards and forwards through the water, particular attention being paid near the edges. For a tank five feet deep and one acre in extent, fifteen pounds of active bleaching powder will suffice. For other purposes the required quantity should be mixed with water in a wooden or cement tank and the mixture allowed to settle, when it is ready for addition to water in the required proportions.

For purification of water on a small scale make a stock solution with 30 grs. of fresh powder in a pint of water, one teaspoonful of this will sterilise 10 gallons of water within 30 minutes.

Preparations like *chloros. chlorion. electrolytic chlorine.* etc., are prepared either from bleaching powder or from brine by electrolytic action. The available chlorine in these preparations varies from 2.5 to 10 p. c.

In order to determine whether chlorination of water has been effective the following test is required :—

Fill a small earthenware or enamelled bowl with the treated water, about half an hour after treatment drop into the water one crystal of iodide of potassium and a few drops of freshly prepared starch solution. If a faint bluish-green colour develops chlorination has been effective. If no bluish colour appears the water requires further treatment.

7. *Catadyn Process.*—Certain metals in infinitesimal doses act as powerful germicide which has been described as the *oligodynamic action.* This action has been taken advantage of in the purification of water, and the commercial "Catadyn" products use silver either in the spongy form or by impregnating unglazed porcelain or sand with the metal so as to increase the area of active surface. In this process minute quantities of silver go into solution in the form of silver ions which attract oxygen from the air dissolved in water and the bacteria are killed. Infected water exposed to the action of catadyn materials showed rapid diminution in the number of viable organisms. Even after heavy infection

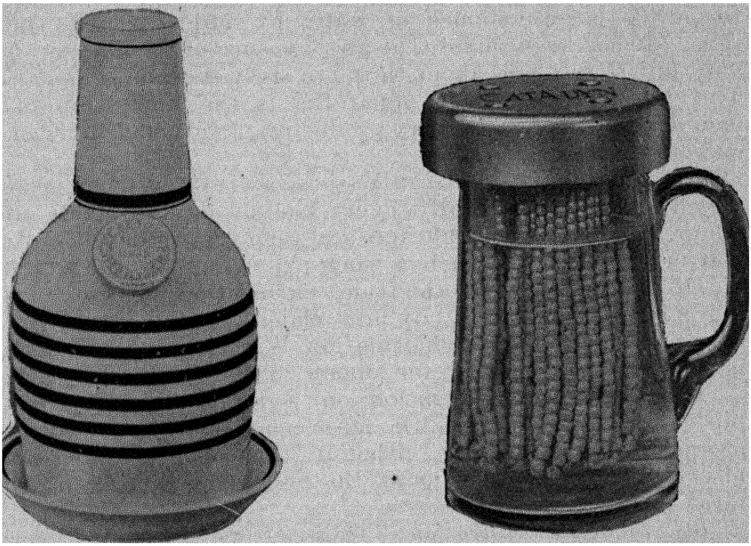

Fig. 5.—Catadyn Sterilising Bottle. Will sterilise 250,000 gallons.

Fig. 6.— Catadyn Bead Type Steriliser.

the water becomes sterile after a few hours. For this treatment only clear water should be used, therefore filters are also necessary. Catadyn treated waters have extraordinary disinfecting powers and can be used in dairies, breweries, hotels, hospitals and for ice-making. It also removes odours. Several forms of appliances for sterilising water are now available. The simplest vessels for disinfecting small amounts of water are white glazed sterilising bottles or red porous earthenware pitchers. The "Bead" type steriliser contains the elements in the form of catadyn covered beads threaded on silver wire. The beads are immersed in any water jug or glass (*see* Fig. 6). The beads are either left in contact for an hour or two, or can be immersed for a few minutes. After removal the water is

allowed to stand for two to three hours to complete sterilisation. The beads are packed in a metal box.

8. *Ozone* is produced by electrical discharges in the atmosphere, and this ozonised air is brought into contact with water. It requires 1 to 3 mgrms. to purify 1 litre of water. It is a powerful germicide, but owing to the expense and the electrical and engineering difficulties involved, this process is not so suitable for the purification of water on a small scale.

9. *The Ultra-Violet Rays.*—Sterilisation of water by *ultra-violet rays* is being largely used on the Continent. The beneficent effect of sunlight in purifying water is believed to be due to these rays and a special apparatus has been made to purify large volumes of water by subjecting it to these rays. It has been found that an exposure of twenty seconds will kill *B. coli*, and about thirty to sixty seconds *B. subtilis*. The chief feature of the apparatus is the immersion of a mercury vapour quartz lamp producing ultra-violet rays in a current of water.

(*c*) *Adsorbents.*—For this purpose activated carbon is used which removes practically every kind of organic taste and odour, eliminates free chlorine, and removes organic colouring matter and iron. The carbon when exhausted may be revived.

Of the different methods of purification of water boiling is by far the safest. By first clarifying the water with alum and subsequent chlorination a perfectly good water is produced which is safe for human consumption.

III. Filtration.—Filtration on a large scale is accomplished in different ways, the most common method being by means of sand filter beds, either in the form of slow sand filters, or in small tanks, as in the so-called rapid or mechanical filters.

(*a*) *Slow sand filtration.*—These filters consist of large shallow reservoirs containing sand and gravel as filtering media, and the water is passed through them slowly from above downwards. This process is called slow filtration in contra-distinction to rapid filtration.

These water filters require extensive tracts of land and are therefore usually situated in the outskirts of the city and located on the banks of a river or a stream. As it is not desirable to run the water directly into the filter beds which may cause choking or clogging of the filters, the water, taken from the stream where there is no source of pollution within a reasonable distance, is first collected in *settling tanks* or large reservoirs where sedimentation occurs and most of the bacteria are destroyed by light and air. This sedimentation is the first step in filtration, and may be simple sedimentation or sedimentation with the addition of a coagulant. In the former process it takes about 24 to 48 hours for the suspended impurities to settle, specially during the rains. The use

of a coagulant helps sedimentation to take place more quickly; and the usual coagulant employed is sulphate of alumina.

This sedimentation has a considerable influence on bacterial life. The number of bacteria is reduced often by 99 per cent., the bacteriological ratio of water is altered by the reduction of the B. coli to a greater extent than other water bacteria, and the typhoid and cholera organisms are devitalised. All these have a marked "levelling" effect on water before it is allowed to pass into "filter beds."

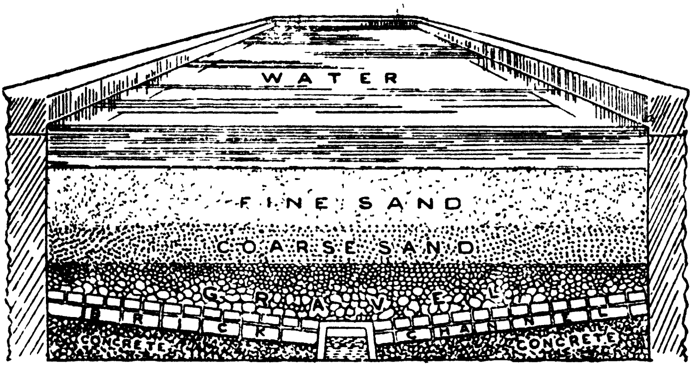

FIG. 7.—SECTION OF A SAND FILTER

Filter Beds.—These are water-tight reservoirs, rectangular in shape, arranged side by side in rows, and may be either open or covered. They are usually about 12 ft. deep so as to contain the necessary filtering materials and water, and leave a margin of 2 to 3 ft. above the surface of the water. The water should be 5 to 6 ft. to prevent excessive growth of algæ which block the filters. They should have perforated tubular drains below for the collection of the filtered water and are filled from below upwards with two layers of bricks arranged in the form of channels for the passage of water; spaces are left between two bricks, which are covered by a second layer. On top of this is a layer of gravel six inches to twelve inches deep, which acts as a support for the upper layer of sand so that it does not work its way down into the under drains. The thickness of the sand layer varies from one to three feet. The surface layer consists of fine sand.

The action of slow sand filters is threefold, *viz.*, physical, chemical and biological. The suspended impurities are strained off by the upper portion of the filter, and a certain degree of oxidation of organic matter is effected by the aid of nitrifying organisms. The real agent which separates the organisms is the layer of colloidal silt and slimy organic

matter known as the "vital layer" formed upon the surface and in the interstices of the sand. This green slimy layer is made up of fungi, algæ, and other low vegetable organisms which form a zoogleal mass upon the upper layer of the sand and appear after three days. Therefore the filter acts best after the third day when this jelly-like layer or membrane is formed. Sand alone is much too coarse to arrest the bacteria, and it is not until the sand spaces are filled with silt and vegetable growth that the bacteria are arrested. Koch has shown that if this surface be removed by scraping, or its continuity affected in any way, as by excessive and irregular pressure, the number

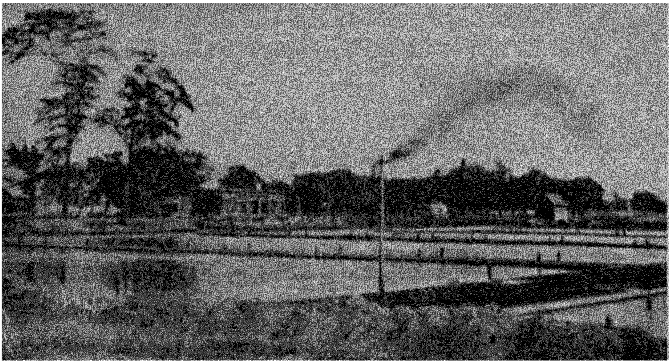

FIG. 8.—FILTER BEDS. Calcutta Water Works at Pulta.

of bacteria which pass through this purifying layer will increase considerably. When, however, this deposit becomes very thick, the filter gets clogged reaching its highest allowable loss of head, filtration becomes so slow as to be uneconomical, and the bed has to be scraped, washed, and cleaned. After this the water should be allowed to stand till a fresh membrane forms before filtration commences again; therefore the first portion of the water should not be stored in the pure water reservoir. At each scraping about a quarter to half an inch of the sand is removed, and when, by repeated cleaning, the thickness of the layer of sand is reduced to about 16 in., the filter is thrown out of action and the bed has to be renewed to its original depth.

Recently purification of drinking water by means of filters made of silver-coated sand has been much used. For this purpose sand-grains should be 0.5 to 1.0 mm. in diameter. They should be washed, dried and calcined in open pans for about two hours and while hot treated with a 2 p.c. solution of nitrate of silver to which a ten per cent. solution of spirit of ammonia is added until the solution

becomes clear. The solution is heated to 50° C. and poured over the sand in the proportion of 2 to 1 of sand. Experiments have proved that the filters act not only mechanically but that the silver acts as a bactericide.

The most important factor in these filters is the rate of filtration. Ordinarily the rate of flow should not be more than 200,000 gallons per acre per hour, or *four vertical inches*, or 50 gallons per sq. ft. per day. When it passes at the rate of 4,800,000 gallons per acre daily it has a vertical movement of 3.94 inches per hour. If however hypochlorite is added to the water one can increase the rate of the filter. The effluent from each filter should not yield more than 100 microbes per c. c. on gelatin plates, and the thickness of sand should never be less than 12 inches.

Sand filtration involves four stages, as follows :—

1. The sedimentation of the grosser particles in the settling tanks.
2. Mechanical obstruction to impurities in the interstices of the filter.
3. Oxidation of the organic matter in the pores of the filter beds.
4. Process of nitrification carried on by the micro-organisms in the vital layer on the surface of the filter.

Control of Filters.—The filtered water collects in channels at the bottom of the filter beds and passes thence through the containing wall by a pipe which leads into the filter "well." The height of water in this well is variable at will, and it is by utilising this method of control that the rate of filtration is maintained at a steady rate of *four vertical inches per hour.* When a filter-bed is first brought into operation there is very little resistance to the passage of water, and if water is allowed to run out of the well by lowering the sill of a penstock, it is found that about half inch lower level of water in the well will cause a sufficient flow through the filter. This half-inch difference of level is known to engineers as the *filtration head or* "working head."

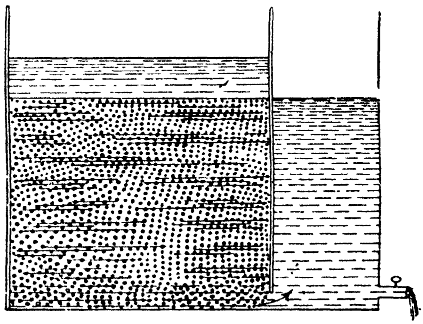

Fig. 9.—Control of Filter Calcutta System.

As the vital layer develops and the filter clogs, this half-inch of head does not give sufficient pressure to draw water through the sand, and we have to increase the working head by lowering the sill still more until even a difference of level of 18 in. will not be enough. When

a head of 18 in. to 2 ft. is reached the rate of filtration is so rapidly reduced that it is better to scrape and reset the filter bed. The methods of control of working head are several, *viz.*—

1. *Calcutta System.*—Here the rate of flow is controlled by a valve in out-flow pipe at the base of the well. The rate depends not only on the size of the valve-opening but also on the height of the column of water in the well. Control of filtration rate is consequently irregular.

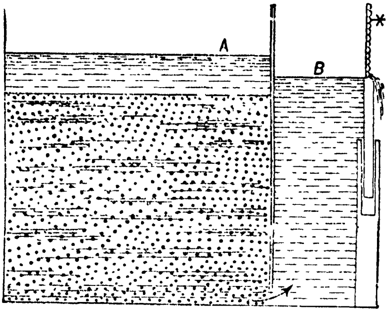

FIG. 10.—CONTROL OF FILTER Penstock System.

2. *Penstock System.*—Here the rate of flow is controlled by varying height of sill. This requires constant adjusting to give even depth of water flowing over sill, but the difference of A B gives a true measure of the working head.

3. *Siphon System.*—Here the rate of flow depends on different lengths of a siphon arm. This is adjusted to choice. The siphon tube is supported on floats on the surface of the well. This gives a constant and automatic result.

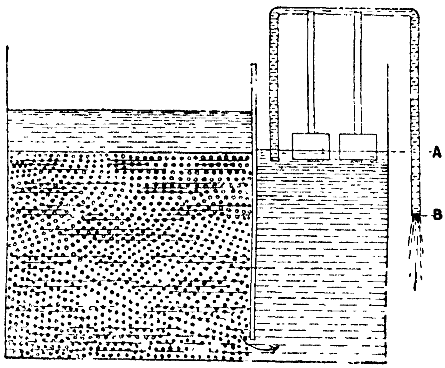

FIG. 11.—CONTROL OF FILTER Siphon System.

The Standard of Purity.—The efficiency of sand filters is determined by comparing the number of bacteria in the raw and filtered water. A good filtered water should not contain more than 100 microbes per c.c. and very few colon bacilli. It is therefore necessary that there should be efficient supervision of all slow sand filters. This should include systematic inspection of the source, gathering ground, pumps, reservoirs, etc. There should be a laboratory with a competent bacteriologist who should make a daily examination of the water sampled from various points of the system. All storage tanks and filter beds should also be under proper control and supervision.

In European countries it has been empirically found that filtered water should not contain B. coli in 50 c.c. of water

and a total bacterial count higher than 100 per c.c. The standard of purity obtained in the Hughli-Chinsura Water Works in Bengal is as follows :—

No lactose fermentors in 60 c.c.......80 p.c.

No lactose fermentors in 10 c.c.......98 p.c.

(*b*) *Mechanical Filters.*—Mechanical or rapid filters include many types of filters that are worked at a rate of flow forty to sixty times greater than that which is usually permitted in the slow sand filters. They include Paterson, Jewell, and Bell's filters. They may be either pressure or gravity type. In the *pressure filter* the chamber is closed and the water is driven through the sand under its own head of pressure. In the *gravity filter* the water is passed through a coagulating basin thence to open filters through which it gravitates and then led to the clear water tank. With the growth of population and in expanding cities it is found that slow sand filters do not adequately meet the increasing demand for filter water. Morever, the difficulty of getting room for slow sand filters, which requires extensive tracts of land, is great. These filters have therefore replaced in many places the slow sand filters. In this process of rapid filtration the following steps are involved, *viz., coagulation and formation of "flock."* and *filtration.*

In this system the place of the vital layer of a slow sand filter is taken by a filtering layer artificially made by producing a flocculent precipitate which with the colloidal silt fills up the sand interspaces, as quartzite sand alone is unable to arrest the passage of bacteria. The absence of silt from raw water is therefore a disadvantage and the alum 'flock' alone cannot form a satisfactory film. These filters therefore are not suited for cleared water.

There are many types of mechanical filters but the following may be taken as a typical cycle of operation.

Raw water is pumped into one or more settling tanks where heavier silt is deposited and a certain amount of natural purification takes place. This water is then led continuously into the plant and the requisite dose of coagulant (aluminium sulphate 1 to 4 grs. per gallon of water) introduced in solution by means of a special gear. The water then passes down a pipe or mixing trough where the coagulant is well mixed and reacts with the calcium bicarbonate (temporary hardness or alkalinity) in the water, forming hydrate of aluminium, a finely divided gelatinous precipitate as follows :—

$$Al_2(SO_4)_3+3CaCO_3+3H_2O=Al_2(OH)_6+3CaSO_4+3CO_2.$$

The treated water flows into a coagulating tank where flocculation takes place during its passage from one side to the other, which occupies a varying period according to the nature of the water.

The partially settled water with as much as possible

of gelatinous precipitate still in suspension is then admitted to a series of rapid filters. The filtering sand is contained in large wooden or iron tanks, and in large installations in special brick built tanks, so arranged that the sand can be washed mechanically. The effluent from the filters then passes through automatic regulating gear and is sometimes sterilised by chlorine gas on its way to the pure water reservoir.

When the filter becomes clogged the sand is violently agitated by means of rakes, compressed air or steam, and filtered wash water is admitted from the bottom and flows away to waste over the top carrying with it the dirty gelatinous film.

After washing, a new film is formed (this can be done in five minutes) and a filter which has become clogged up can be washed, filmed and ready for service fifteen minutes after. After washing a filter it is advisable to turn on a small quantity of alum solution to enable the filtering film to be formed quickly. Five pounds of sulphate of alumina will carpet a filter 18 ft.$\times$10 ft., *i.e.*, 180 sq. ft., and form the initial film which is then continually built up by the incoming water.

Continuous addition of alum, which is done in most of these filters, does not give better results than when the filters are worked on a 'free wheeling' basis, *i.e.*, alum roughly at the rate of three grains per gallon is added only from 5 a.m. to 12 noon, while from 12 noon to washing time at 4.30 p.m. the filters are run without it. It has been found that once the film is formed, addition of more alum is not required; there is therefore a considerable saving of alum and consequently of expense.

The Paterson Gravity System of rapid filtration comprises four distinct processes :—

1. *Addition of Chemicals.*—The automatic measurement of the raw inlet water and the addition of sulphate of alumina solution in proportion to the flow, is effected by the chemical measuring gear.

2. *Mixing of Chemicals.*—The treated water passes down a mixing trough provided with baffle plates where the solution of alum is mixed thoroughly with raw water.

3. *Coagulation and Sedimentation.*—This is effected in the coagulation tanks where most of the suspended and colloidal matters are precipitated and run off to waste through sludge pipes. As explained above this is wrong in principle although usually followed.

4. *Filtration.*—The removal of the coagulated impurities and bacteria by rapid filtration.

After the water is allowed to settle in settling tanks for about four days the raw settled water is admitted through inlet pipes to the filter and enters the measuring gear. Here

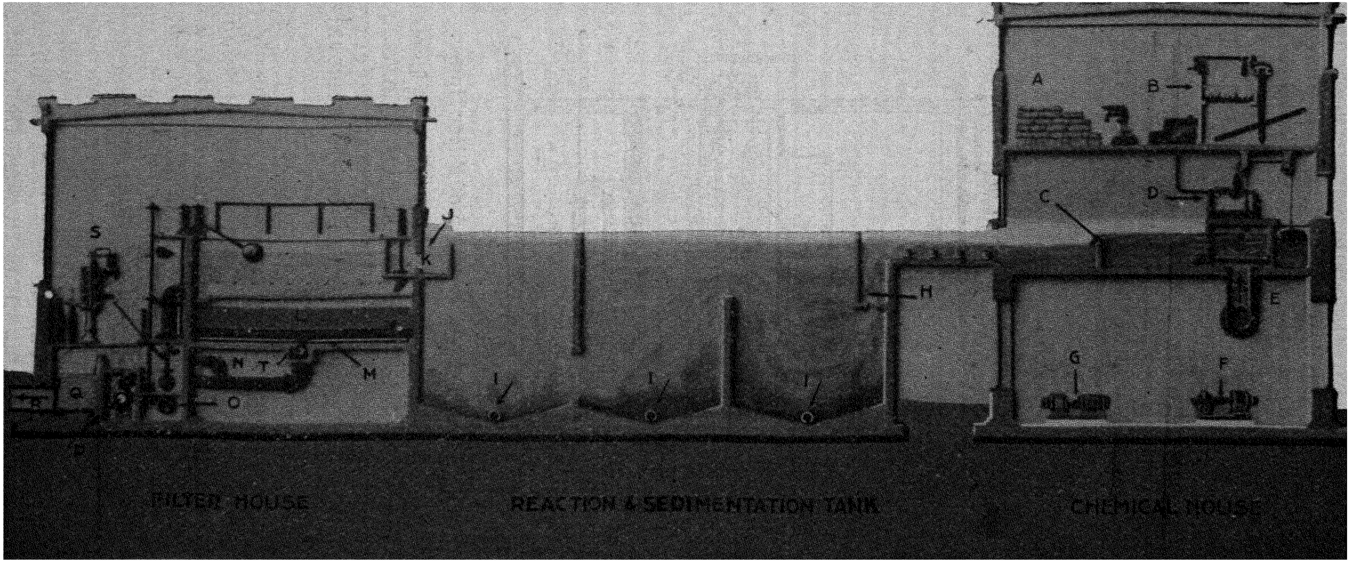

FIG. 12.—SECTION OF RAPID GRAVITY FILTRATION PLANT (Paterson System)

A, Alumina store ; B, Alumina tank ; C, Measuring weir ; D, Alumina proportioning apparatus ; E, Crude water inlet ; F, Filter waste water pump ; G, Air compressor ; H, Distributing channel ; I, Scour pipes ; J, Collecting channel ; K, Inlet valve ; L, Filtering medium ; M, Pure water collecting system ; N, Air ; O, Filter wash discharge ; Q, Chlorine distributor ; R, Filter water outlet ; S, Chloronome ; T, Header.

sulphate of alumina is added to the water which flows down the trough and enters the distribution channel and then into the coagulating tanks. The bottom of these tanks has a deep slope so that the precipitate collects near the sludge pipe and is washed away to waste. The water enters the coagulating tank near the bottom and is drawn off from a pipe near the surface and is passed into the filters. The length of time the water remains in the coagulating tanks depends on the state of the water and the time of the year.

Each filter is rectangular in shape, measuring 16 ft. by 10 ft., and the water is distributed on to the surface of the sand by means of an iron trough.

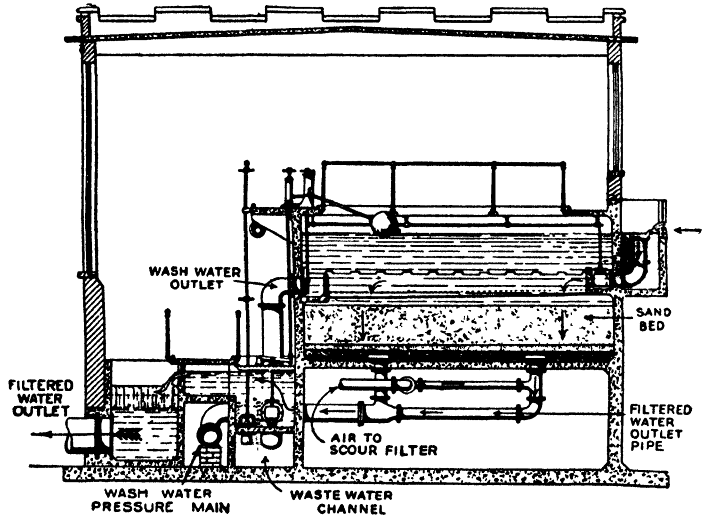

FIG. 13.—PATERSON RAPID FILTER. Section of Filter House.

Besides the mechanical property of entangling bacteria and suspended matter, hydrate of alumina fixes the colouring matter, rendering it insoluble, and so effects decoloration and precipitation. This results in the entire removal of colour from peaty water.

The operation of washing is done as under :—

The inlet valve is shut off and the level of water in the filter is gradually lowered until it is automatically shut off by a ball valve. The outlet valve is then closed and the waste valve above the filter is opened. Air at about 15 lb. per square inch is then admitted from the bottom of the filter and rises through the sand, agitating the bed thoroughly.

This agitation continues for 1 or 2 minutes according to the season of the year and is then shut off. Immediately after, pure wash water at about 40 feet head is admitted from the bottom and flows upwards through the sand and

away to waste carrying with it the dirty film and other impurities. This washing is continued for 1 to 3 minutes.

The waste valve is then closed and water from the coagulating tanks with a supplementary feed of sulphate of alumina is then admitted and the new film allowed to form while the effluent from the filter is run to waste for a few minutes before being admitted to the pure water channel. This channel opens into a well-protected underground reservoir made of brick and cement and provided with openings for ventilation.

Just before allowing the water to pass into the filtered water reservoir a definite quantity of hypochlorite of lime is added.

The advantages claimed for rapid filters are:—

1. Small area of land is required.
2. No settlement tanks are necessary.
3. Filtration is continuous.
4. The filtering material does not require changing, and is thoroughly cleaned in a few minutes.
5. They are cheap and efficient, and therefore especially adapted to those cases where the cost of land is high, and where the water is so turbid as to require large settling tanks.

Common defects of mechanical filters are:—

1. Coagulating tank is too big and the "flock" settles out before it reaches the surface of the filter where it is wanted.
2. Overwashing. It is not necessary to wash away all the existing "flock" but it should be allowed to resettle.

It should be noted that the performance of the pressure filters even under most careful management and supervision is irregular. When dealing with a fairly clear raw water the addition of full dose of alum never arrests more than 90 p.c. of bacteria and often less, a result equalled when no alum is used. It is therefore desirable when the water is used for drinking to save the money spent on alum and spend it on chlorination. The addition of 0.4 part per million to the filtered water would give a sterile water.

The Jewell Gravity Filter.—This is circular in section and is made of steel. The layer of sand or crushed quartz is about three feet deep resting on a thin bed of gravel which in turn is supported by the branching outlet pipes with bronze strainers embedded in concrete. The cycle of operation is as described above. The washing is effected by closing the inlet and outlet valves and opening the washout valve. Filtered water is then admitted under sufficient pressure from below which percolates upwards through the sand which in the meantime is vigorously stirred by rods depending from four radial arms revolving about a central shaft. The rakes, as they are generally called, are worked by means of a small engine, turbine or motor.

The Jewell Pressure Filter.—The term "pressure filter" is used to denote a filter which is entirely enclosed, so that it can be placed on the pumping main. It does not imply that water is forced through the filter with a big difference of pressure on each side of the sand and film. The filtration head must never exceed the maximum allowed

in a gravity type of filter. These filters are very convenient for commercial installations where they have to clean turbid water and render it fit for use in boilers, etc.

The action of a *pressure filter* is identical with the gravity filter, the only difference being that the former is entirely closed. The raw water which receives its dose of coagulant by means of a pump, passes on to the top of the sand and forms a gelatinous film without previously passing through a coagulating tank. These filters therefore clog up more rapidly than gravity filters as all the work is done by the filter itself and therefore require to be cleaned more frequently.

The Candy Filter.—Since oxidation plays a very important part in the purification of water containing organic matter, the object of this filter is to replace the ordinary inert filtering medium, sand or crushed quartz, by one that has high adsorptive power. It also contains oxygen which can communicate itself to the percolating fluid. Two materials known as *Polarite* (magnetic oxide of iron) or *Oxidium*, substances similar to charcoal in their power of adsorbing air,

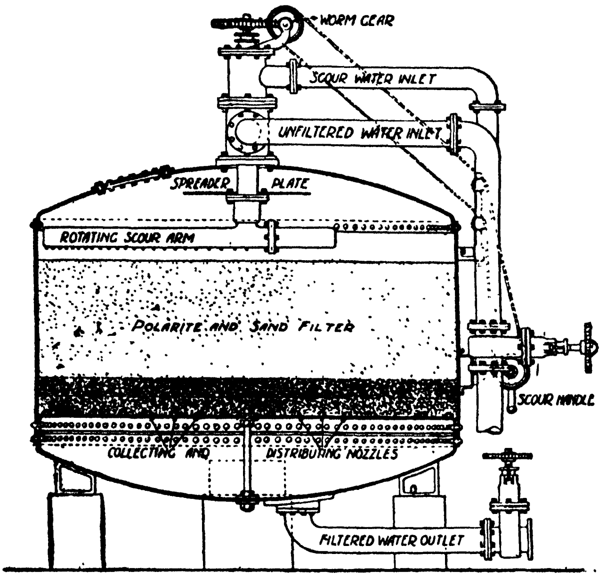

FIG. 14.—SECTION OF CANDY SINGLE-BED FILTER

have been used with success in the purification of waters containing iron, peaty matters and small traces of sulphuretted hydrogen.

The filtering media are divided into three layers; the lower layer is of sand and fine gravel similar to an ordinary filter. The middle layer is of polarite and the top layer of sand and gravel. The Candy filter is a pressure filter. The raw water after having received its dose of alum comes in under pressure and passes over the first layer of sand where a layer of film is formed and where most of the suspended impurities are deposited, leaving the polarite to deal with the oxidisable matters. Below the polarite is the finishing layer of fine grit to entrap any oxide of iron that may have separated. After running some hours means have to be provided to recover a fresh supply of oxygen when the polarite has itself been reduced to a lower oxide. The filtering layers are first cleansed by a reverse current of water. No rakes or

stirrers are used, the pressure of water being sufficient. After running for ten minutes the filter is drained and air is allowed to enter. Water under pressure is then forced in from the bottom of the filter so as to compress the air and so promote its adsorption by the polarite and also increase its solubility in the water with which it is in contact. This process is repeated. The time required for washing is about ten minutes and for aeration about eight minutes, after which the filter is ready for use.

Chlorination of Municipal Water Supply

The treatment of municipal water-supply by chlorination is a modern process and was first used at Lincoln by Houston to disinfect the water works system which had become infected by typhoid organisms. Subsequently the use of chloride of lime for purification of water both by itself and in conjunction with filtration became very popular in America. During the last war it was used with much success. Indeed during the war the water-supply of London was chlorinated, primarily as an emergency measure, but successful and economical results obtained led to its adoption as a routine process. Its use has now been extended to many towns in India, *viz.* Simla, Delhi, Calcutta, etc.

For the treatment of water, chlorine is usually utilised in one of the following forms:—(1) As a hypochlorite, such as bleaching powder; (2) in the gaseous form; and (3) as chloramine. There are however certain disadvantages attendant on the use of hypochlorite, *viz.*, (*a*) it is unstable, only $33\frac{1}{3}$ p. c. of chlorine being available under the best conditions; (*b*) the variation in the chlorine content due to climatic conditions militates against precision of application; and (*c*) its use involves the preparation of pastes and solutions entailing labour and special equipment When used in the gaseous form chlorine is free from these objections but requires a delicate plant for efficient working. Under the patent name of "Chloronome" the Paterson Engineering Co. have devised a special apparatus for regulating, measuring and administering chlorine gas for water-supply, and in this form is largely used in conjunction with various forms of rapid filters. Chlorination of water on a large scale can only be used economically when the labour required

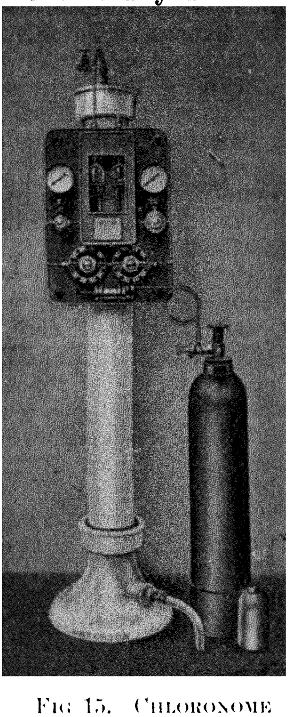

Fig 15. Chloronome

for mixing the solution is cheap. But unless under expert control the dosage will be irregular from either over-dose or under-dose.

Chloramine (NH_2Cl) produced by the interaction of ammonia and chlorinated lime is one of the most powerful germicides known, and is probably the cheapest form in which chlorine can be utilised for water treatment. Ammonia tends to prevent the chlorine from being used up too rapidly by various substances in solution in water and allows it to act better upon the micro-organisms present.

The dosage required depends upon a number of factors, the most important being the purification desired, the amount of oxidisable matter present, the contact period, the temperature of the water, and the method of admixture. Further, if chlorination is used in conjunction with other forms of purification the dosage required will be smaller in proportion to the purification effected by the other process.

In the various processes of water treatment for public supply there are many difficulties which have to be overcome arising through the varying character and quantity of the organic contents of the water. This specially applies to the sterilisation of water by means of chlorine or hypochlorites. Chlorinated water sometimes acquires the unpleasant taste of iodoform, due to the absorption by the water of gases or other substances from the air, either directly, or indirectly through the medium of rain fall.

The taste and odour of chlorinated waters are either chlorinous, due to an excess of chlorine, or that of iodoform. A minium of 0.3 part per million may make the water chlorinous. Iodoform taste is due to the presence of some constituent in the atmosphere which combines with the chlorine added to the water. This constituent is probably phenoloid in character derived from gas works or from imperfectly burnt coal. Houston and Adams have shown that the air in London contains substances which when absorbed by water react with chlorine to produce an iodoform taste. In fact rain water may absorb enough of these substances to give, when added to tap water in the proportion of 1 p.c., an iodoform taste in the presence of free chlorine.

The bad taste and odour of water are removed by ammonia chlorine, activated carbon, aeration, super-chlorination, ozone and potassium permanganate. Ammonia-chlorine (chloramine) is extensively used as it has the advantage of preventing chlorine and chlorophenol tastes, retards or prevents the aftergrowths, and reduces the amount of chlorine necessary to sterilise the water, is possibly more effective than chlorine alone as a bactericide and allows a high residual chlorine to be maintained. It is generally applied after filtration, ammonia being first added as ammonium

sulphate or ammonia solution in the proportion of 1 to 3. Super-chlorination followed by de-chlorination by sodium bisulphite, sodium thiosulphate or SO_2 is used when there is considerable pollution or the natural taste or odour of the water is very pronounced. In using these measures it should be remembered that each taste and odour condition is an individual problem requiring careful study to determine the best and most economical method of treatment. Activated carbon is used for the removal of practically all kinds of organic tastes and odours, chlorophenol and algal tastes, organic colouring matter and iron. Aeration is also used for the removal of certain tastes but it is not successful in all of them. The iodoform taste is removed by treating the water with potassium permanganate, before, with or after the chlorine in the proportion of 1 in 50 millions.

Chlorination and filtration.—1. The initial cost of chlorination is cheaper by 1 to 5 p.c. of filtration plant of equal capacity and efficiency.

2. The maintenance cost is in the same ratio.

3. Chlorination provides positive protection against accidental infection.

The most economical method of purifying polluted supplies is to rely upon chlorination for bacteriological purification and depend upon filtration for the removal of turbidity, colour, etc. In this way slow sand filters could be operated at much higher rates, and the enlargement of purification works which would otherwise be necessitated by an increased population could be avoided.

Chlorine treatment should be regarded as a supplementary process to, and not as a substitute for, filtration. Whenever possible the chlorine should be applied to the filtrate, because

(*a*) the filtered water has a more constant organic content than the raw supply, and the dose can be regulated better ;

(*b*) the amount of chlorine required is considerably reduced ; and therefore

(*c*) less likely to impart any taste to the water.

Domestic Filters.—A domestic filter to be satisfactory must keep back all germs, and the substances that are used for the purpose are some form of infusorial earth, clay, porcelain, or patent combinations of porcelain and clay. Water filtered through animal charcoal becomes decolourised, but the charcoal loses its oxidising property and adds to the water phosphate of lime which favours growth of bacteria.

The essential features for a good filter are :—

1. It should be strong and compact and simple in construction to allow of easy cleansing and re-adjustment.

2. It should be constructed of some stable and efficient material having the power to purify water to a high degree.

3. The filtering medium should not require frequent

changing, and neither it nor the receptacle should impart anything injurious to the water.

4. It should be cheap and its purifying power fairly lasting.

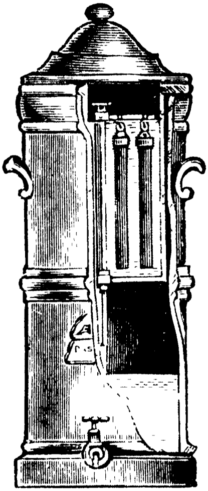

FIG. 16.—PASTEUR CHAMBERLAND FILTER

1. *The Pasteur-Chamberland Filter.*—This consists of porous tubes or bougies of unglazed porcelain. These tubes can be screwed on to a tap. Its action is purely mechanical, as it separates even very fine particles of suspended matters and bacteria. Unless there is some pressure the filter acts slowly; 20 to 40 pounds of pressure per square inch will filter about three quarts of water per hour. The candles should be cleaned by brushing with hot water and then sterilised by boiling in water containing some sodium carbonate. It is a perfectly reliable filter, as it frees water of all bacteria. Muddy water should first be cleared by passing it through closely packed coarse sand or other material, otherwise it will form a coating outside the filtering material and will block the pores.

2. *The Berkefeld Filter.*—This consists of a cylinder made of infusorial earth; but the cylinder wears thin by constant cleaning and gradually ceases to filter efficiently. The candle should be sterilised by boiling every third day. Muddy water, if not previously clarified would clog up such a filter rapidly.

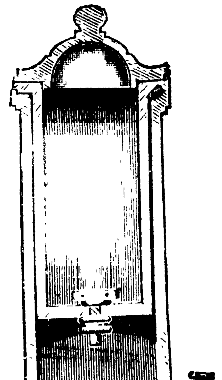

FIG. 17. BERKEFELD FILTER

Of these two filters the Pasteur is more reliable and durable than the Berkefeld, but the Pasteur filters very slowly and is practically useless unless the water is put under pressure. Horrocks has found that when sterile water is inoculated with typhoid bacilli and run daily through a Berkefeld filter, the bacilli appear in the filtrate in one to two weeks; this is not the case with the Pasteur. The Berkefeld, on the other hand, requires no additional pressure and is more rapid in action, but the pores being more open, after it has been in use for a few days, may allow some organisms to appear in the filtrate. This perhaps, is due rather to the growth of organisms in the pores of the filter-candles than to their direct passage. Being made of infusorial earth they are more liable to fracture.

3. *The Four-ghurra Filter.*—It consists of four unglazed earthenware vessels placed one over the other on a wooden frame, each one having one or more holes at the bottom stuffed with cotton-wool or straw. The top one contains the unfiltered water which has been strained through muslin. The second one is half filled with powdered charcoal, and the third one contains fine sand and a layer of small gravel underneath. The lowest one is the receiving vessel. This filter is largely used in villages, but it should be avoided, as it is not reliable and gives a false sense of security.

The idea that domestic filters do not require any attention or cleansing and that the filtered water is always above suspicion is erroneous. For the pores of the filter very often get clogged with foul materials which afford a suitable nidus for bacteria to flourish in, and the so-called filtered water becomes decidedly worse than the original one. This happens particularly when animal charcoal is used as a filtering medium.

Public Swimming Baths.—As a rule there is no proper arrangement for purification of the water in these baths, the tank being only refilled with fresh water and the frequency of refilling depends upon the physical appearance of the water. But the colour of the water gives no indication of its bacteriological purity, although transparency of the swimming-bath water is also equally important. Bacteriological examination of bath water has shown the presence of the following organisms derived from (1) *skin contamination, viz.* staphylococcus pyogenes aureus, epidermidis albus and members of the proteus group; (2) *normal saliva, viz.* streptococcus salivarius, staphylococcus pyogenes aureus and a gram negative diplococcus; (3) *fæcal contamination, viz.* B. coli communis, B. pyocyaneus, streptococcus fæcalis and proteus. These organisms though for the most part are the normal saprophytes of the human body, are yet capable, under certain conditions, of becoming pathogenic, specially when resistance is lowered by chill due to exposure and too long stay in the water. Cases of conjunctivitis, sinusitis, otitis media, infectious sore-throat have been attributed to the use of swimming bath. Though rare, typhoid fever, dysentery, skin diseases, vulvo-vaginitis, trachoma, etc., have been traced to the use of public swimming bath. The American Public Health Association, through their Committee of Bathing Places, exercise a powerful influence on the adoption of a high standard of bath sanitation. They have recommended a system of regulations, as regards bath construction, pool disinfection, sanitation, the use of continuous filtration and supervision of bathers. Natural purification can only be possible when the tank is large and contains natural pond vegetation, nor is it possible to keep the water clean by the fill and empty system. It is therefore necessary that the water should be subjected to a process of continuous

and rapid filtration combined with aeration and chlorination. Chlorine is the most reliable agent for disinfection, and the concentration necessary to keep the water pure is 0.2 part per million. Braxton Hicks (*British Medical Journal, Sept. 30, 1933*) and others maintain that when the concentration of chlorine is below 0.3 part per million of water, sterilisation is imperfect. On the other hand when it is above 0.5 part per million the bather complains of smarting of eyes and nausea if the water is swallowed. Moreover the atmosphere of the bath becomes nauseating and irritating. In order to maintain constant chlorination at a proper figure it is necessary that some automatic device should be employed, and strict supervision made of the bathers. Every bather before entering the pool should clean himself by the use of soap and shower bath. The importance of attention to the calls of nature before the preliminary ablution, and the avoidance of expectoration and blowing water out of the mouth in the bath are a few details which should be enforced.

THE EXAMINATION OF WATER

For hygienic purposes the examination of water is generally done under the following heads :—

A. Physical examination.
B. Chemical examination.
C. Microscopical examination.
D. Bacteriological examination.

Collection of Sample.—Take a clean Winchester quart bottle of white or pale green colour with a stopper or a perfectly new and clean cork. Rinse it three or four times with the water to be examined. If the sample has to be taken from a stream, lake, or well, the stopper should be inserted and the bottle placed well under the surface of the water and then filled with water, care being taken not to stir up any sediment. In rivers take from midstream or at a reasonable distance from the shore. In towns the sample should be taken from the mains or stand posts or taps. When collecting from a tap, allow the water to run for a few minutes before taking the sample. Fill the bottle quite full and replace the stopper which will make room for itself.

No sealing wax or grease should be applied to the stopper. It is best secured by a covering of clean linen or by an india-rubber cap and then sealed.

The bottle should be kept in a cool dark place, if possible in an ice box. The examination should be undertaken as early as possible after the collection of the sample.

The following information should always be furnished with the sample of water :—

(*a*) Source of water, *i.e.*, whether from a tank, or a well, etc.

(*b*) Geological formations of the neighbourhood; so far as known.

(*c*) In case of a well, its depth, diameter, strata through which sunk, how used, and depth of the water.

(*d*) Possibility of impurities reaching the water; in case of a well its distance from cultivated land, cesspools, drains, privies, etc.

(*e*) In case of surface or rain water, method in which the water is stored.

(*f*) Meteorological conditions, whether there has been any recent rain or flood.

(*g*) A statement of any existing water-borne disease in the neighbourhood, or special reasons for requiring analysis.

Each bottle should be distinctly labelled to correspond with the official letter.

A. **Physical Examination of Water.**—This by itself cannot form a basis of opinion, but brilliant, clear, non-smelling and highly aerated water only is fit for human consumption. Note the following :—

(*a*) *Colour.*—Pour the water into a colourless glass tube about 2 ft. deep, placed on a white plate, and note the colour. The longer the tube the better is the colour noticed. In small quantities pure water is colourless, but has a greenish tinge when viewed in bulk. A yellow or brown colour generally indicates contamination with animal organic matter, mainly sewage, but may also be due to vegetable matter or salts of iron.

(*b*) *Clearness.*—Shake a small quantity of water and note whether it looks hazy or not. Heavy sediments rapidly fall to the bottom. Turbidity is generally due to clay or silt, minute particles of organic matter, micro-organisms, etc.

(*c*) *Lustre or brilliancy.*—Some water is distinctly dull or of slimy appearance. Clear and sparkling water contains CO_2 and air.

(*d*) *Taste and smell.*—The purest water is without any taste or smell but it is insipid. Gases held in solution and mineral matter impart the taste to most waters. Any smell in water is objectionable, and is chiefly due to the growth of algæ and protozoa. Growth of algæ gives to the water a disagreeable and nauseous taste and smell. *Crenothrix* and *Cladothrix dichotoma* also impart a disagreeable odour and taste. An offensive water in a well or tank indicates stagnation at the bottom or the presence of dead animals. Hydrogen sulphide and other inorganic compounds may also impart offensive odours to the water in deep wells. Chlorinated waters sometimes acquire an iodoform taste.

B. **Chemical Examination of Water :—***

(*a*) *Reaction.*—This is taken with litmus paper, or by dropping a solution of phenolphthalein which when added to water having the faintest trace of alkali will turn it a delicate pink. Nowadays the acidity and alkalinity of water is expressed in terms of hydrogen-ion concentration. At 21°C. pure water contains 1.0×10^{-7} of a gramme of free hydrogen-ion per litre which is represented by "CH" or hydrogen-ion concentration. Such negative figures are difficult to deal with in practice, so the potential of hydrogen-ion concentration is taken as the standard. The hydrogen-ion concentration potential or pH is the decimal logarithm of the reciprocal of CH, and in the case of freshly made distilled water the pH = 7.0. But its equilibrium is very soon disturbed and it becomes acid by absorbing CO_2 when its pH becomes lower, or may become alkaline, when its pH becomes higher.

Most waters are neutral or faintly alkaline. Peaty waters are frequently acid. Acidity may be due to humic acid or to CO_2, if due to the latter it will disappear on boiling. Alkalinity may be due to the presence of sodium, calcium or magnesium carbonates in solution.

(*b*) *Hardness.*—This is due to the presence of carbonates of calcium and magnesium held in solution as bicarbonate by the dissolved CO_2. This hardness is removed by boiling. "Total hardness" is that which is present before boiling, and that which remains after boiling is called "permanent hardness." The amount of hardness is generally expressed in degrees. Clark's soap test is employed in determining the amount of hardness. This consists of a standard solution of soft soap in a mixture of methylated spirit and distilled water in the proportion of 4 and 6 respectively.

To determine Total Hardness.—Take 100 c.c. of water in a stoppered bottle, to this add soap solution from a burette with constant

*This description is given for ready reference only. For more complete information the student should consult "Public Health Laboratory Practice" by Stewart and Boyd.

shaking till a sufficient lather is produced on the surface and remains intact for five minutes. The number of cubic centimetres of soap solution used, minus 1 c.c. gives hardness per 100,000 parts. 100 c.c. of distilled water would require 1 c.c. of standard soap solution to form a lather.

Each degree of hardness necessitates a loss of a pound of soap for every 1000 gallons of water.

Permanent Hardness.—Boil 100 c.c. of water for 15 or 20 minutes, filter and add distilled water to make up the loss by evaporation. The hardness is estimated with standard soap solution as above.

Temporary Hardness.—The difference between the total and permanent hardness is the temporary hardness.

According to Clark's tests each degree corresponds to the soap destroying power of 1 gr. of $CaCO_3$ in 1 gallon of water. When it is less than 10 degrees the water may be considered soft or moderately soft. when 10 to 15 degrees moderately hard, when 15 to 20 degrees hard, and over this figure very hard.

(c) *Chlorides* are always present in small quantities in all waters except distilled water. Near the sea coast rain water may also contain traces. It gives a white precipitate with a solution of nitrate of silver. The examination is done on a white porcelain dish and the water must be neutral or faintly alkaline. If the water is acid it should be made alkaline with sodium carbonate as silver chloride is soluble in acid The silver nitrate solution is dropped into a measured quantity of water tinted a faint yellow by the previous addition of a few drops of a solution of chromate of potash. As long as there is chloride present in the water white precipitate of silver chloride is formed, but the moment the amount of soluble chloride is used up the liquid acquires a reddish tint from the formation of red silver chromate.

Chlorides are derived from sea water, sewage (urine) or from salts in the soil. It is impossible to draw any inference as to sewage contamination from the presence of chlorides alone unless one knows the amount ordinarily present in water from the same source. Although sodium chloride is found in the urine, considerable pollution must take place before it can be detected by an increase of the chlorides.

(d) *Nitrites.*—The presence of nitrites indicates putrefaction of nitrogenous organic matter as a result of bacterial action. Their presence is an evidence of a transitional stage in the oxidation of organic matter between ammonia and nitrate, *i.e.*, incomplete oxidation of protein. They are however never present except in small quantities, as they are soon converted into more stable nitrates. Therefore water containing nitrites, except when not due to the presence of iron, should always be condemned. The presence of nitrites may also be due to the reduction of nitrates by ferrous salts. During the decomposition of nitrogenous organic matter, a large part of the nitrogen passes off in the gaseous state, the remainder along with hydrogen forms ammonia compounds. Nitrites are detected by adding to 100 c.c. of the sample dilute sulphuric acid and a few drops of metaphenylene-diamine, when a yellow colour is produced on standing.

(e) *Nitrates.*—Nitrates are the end products of oxidation of all animal matters. If nitrates are present in large amount and ammonia is very small, the import is that the water has been contaminated before and the ultimate product is left behind. The presence of nitrates alone indicates that the contamination is of long standing. Sometimes their presence may be due to water which has permeated a stratum containing nitrites, *e.g.*, oolite, red sandstone, etc. Nitrates and nitrites are never present in raw sewage, and if they are found in water with an excess of ammonia it means that the water has been contaminated with sewage or animal refuse.

Test.—For this two solutions are required (*a*) 0.1 grm. of naphthylamine in 20 c.c. of distilled water to which 150 c.c. dilute acetic acid is added; (*b*) 0.5 grm. of sulphanilic acid in 150 c.c. of dilute acetic acid; 1 c.c. each of above solutions added to 50 c.c. of the sample gives a pink colour if nitrates are present.

(*f*) *Ammonia* is detected by adding Nessler's solution, which gives a yellow or brown colour according to the amount present in the water. Sewage and manurial matter yield free ammonia on distillation, but by the action of an alkaline solution of potassium permanganate on the albuminous matter a further quantity of ammonia may be detected. This is called *organic or albuminoid ammonia*, as distinguished from *free or saline ammonia*. Traces of ammonia may be detected in almost all waters, especially rain water; therefore its presence alone cannot be taken as an indication of animal pollution. Besides this, water which has been stored for some time in metal vessels will yield ammonia, due to the reduction of nitrate by the metal (as zinc, iron, lead). But in these cases traces of metal can also be detected. These impurities absorb much oxygen from an acid solution of potassium permanganate, called "oxygen absorbed." The amount of oxygen required to oxidise organic matter in a good water should not exceed 0.5 part per million. But in upland surface water this limit may be exceeded owing to the presence of organic matter of harmless nature. Iron salts, sulphuretted hydrogen and peaty waters also absorb oxygen. Similarly variations in the temperature and reaction of the water make the permanganate solution part with its oxygen readily. The determination of "oxygen absorbed" alone is not a reliable index of the real amount of pollution present. The amount of free and albuminoid ammonia and of "oxygen absorbed" should be considered together in forming an opinion as to the purity of water.

Tests. (i) *Free Ammonia.*—Place 250 c.c. of water in a boiling flask and distil over 50 c.c. The amount of ammonia is determined by the process of "Nesslerisation," which consists in adding to the distillate 2 c.c. of Nessler's solution, and imitating the depth of colour produced by adding Nessler's solution to pure distilled water to which definite quantities of solution of ammonium chloride has been added. The water remaining in the retort is used in the test of

(ii) *Albuminoid Ammonia.*—Distil over another 50 c.c. and pour into the distilled water bottle. Add 25 c.c. of alkaline potassium permanganate solution and distil off two 50 c.c. Nesslerise as before.

The amount of ammonia obtained in the above two experiments multiplied by 0.4 gives the ammonia in 100,000 parts of water.

(*g*) *Copper.*—To 100 c.c. of water add a few drops of acetic acid and 2 c.c. of a fresh solution of potassium ferrocyanide, when a chestnut-brown colouration is obtained.

(*h*) *Lead.*—If no reaction is obtained in the above for copper, test for lead. (i) Take 100 c.c. of water, acidify with acetic acid and add a few drops of potassium chromate and stir. A yellow turbidity indicates the presence of lead. If lead is present in fair amount a yellow precipitate is obtained. (ii) Add H_2S to water, if there is a trace of lead it tinges it brown, and forms a black precipitate when much lead is present. It is not affected by acids.

(*i*) *Iron.*—If neither copper nor lead is detected, test for iron. Take 100 c.c. of water, add to it 5 c.c. each of nitric acid (1 in 5) and 10 per cent. solution of potassium sulphocyanide when a dark red colour is produced. A dark colour is produced by ammonium sulphide, and a blue colour by potassium ferrocyanide.

Iron is sometimes present in natural waters when it gives the water a chalybeate taste. It is present in tube well and deep well water. Its presence causes hardness of water and deposit of iron oxide. It may occur both in organic and inorganic forms, the organic salts may be present in colloidal form. Its presence up to 0.25 gr. in

a gallon can be detected by taste and should be condemned. Iron is removed by aeration and subsequent sedimentation and filtration.

Total Solids in water.—Take a known quantity of water, say 100 c.c., and evaporate to dryness on a weighed platinum dish. Weigh the dish with the residue and the increase in weight is the weight of the solids. It is better after the evaporation to transfer the dish and its contents to an air-bath heated to about 250°F. by which the water residue is thoroughly dried. The basin is then withdrawn, rapidly cooled and weighed. Increase in weight is the weight of the solids. After weighing the perfectly dry residue, the contents may be gently ignited and any change of colour noticed White incrustation indicates mineral matter, while charring indicates organic matter; and the smell evolved may give a rough idea as to whether the organic matter is of animal or vegetable origin.

(k) Lime is present in most waters as bicarbonate or sulphate. When in excess it makes the water hard and causes constipation. The presence of a small amount of lime either as bicarbonate or sulphate in the water is beneficial. Entire absence of lime salts makes the water very soft.

Its presence is detected by the addition of ammonium oxalate, when it will make the water turbid or give a precipitate according to the amount present.

C. **Microscopical Examination of Water.**—This is best done by centrifugalising the water, when all its suspended matters fall to the bottom of the tube. The grosser matters, as clay or sand are easily recognised by boiling the water, when they sink rapidly to the bottom. Sediments can also be obtained by allowing the water to stand for some time in a conical vessel. Suspended sand or clay gives yellowish white turbidity, sewage generally a light brown, and vegetable matters or peat a blackish colour. The presence of spores or mycelia is due to contamination with sewage, and the most suspicious elements are the remnants of vegetables used for food, *e.g.* spiral cells of cabbages, cauliflowers, etc. Detection of these cells, as also of fibres of cotton, linen, wool, hair, starch granules, etc., can be made under a microscope. The presence of parenchymatous tissues, spiral cells, and yellow elastic tissue indicates contamination with fæces. Animal substances, *e.g.* wool, hair, yellow elastic tissue, etc., generally indicate recent contamination.

D. **Bacteriological Examination of Water.**—A bacteriological examination of water is undertaken to find out the purity or otherwise of a sample of water and of its fitness for drinking purposes. It is well known that drinking water is often polluted with organisms of many water-borne diseases, and produces in man, when such a contaminated water is taken, diseases like cholera, typhoid fever, dysentery, etc. Besides these disease producing organisms, water may also contain various kinds of worms or their eggs, which in man give rise to various morbid symptoms.

Various kinds of bacteria are present in water. Some are present in all waters, however pure the water may be; these are the natural *water bacteria*, and their presence is of no sanitary significance. Then there are the *soil bacteria*, added to water from soil washings. Finally the *sewage bacteria*, found in water polluted with sewage or excreta of men and animals. The object of bacteriological examination is to ascertain the presence or otherwise in water of organisms derived from sewage.

Roughly speaking two classes of organisms are present in sewage: (1) pathogenic organisms like typhoid, and (2) the bacteria normally present in stools like *B. coli.* Unfortunately the methods at present available for the isolation of the pathogenic bacteria are both difficult and uncertain. Further, a water that is occasionally polluted with sewage may not show these germs at the time of analysis, as the latter may not always be present even in sewage, or they may have

disappeared from the sample. Consequently if search is made only for these organisms a dangerous water may be passed as fit for consumption, on the ground that at the time of analysis no pathogenic organisms were fonnd. For the above reasons these specific organisms are not generally sought for in routine water analysis. The analyst is mainly occupied with the detection and enumeration of the sewage bacteria. It has been ascertained with a fair amount of certainty that in sewage a particular class of organisms, called *B. coli*, predominates over others, and that it is not present in places which have not been subject to sewage contamination. The typical *B. coli* may be defined as a short, non-sporing, slightly motile Gram-negative bacillus, fermenting glucose and lactose with acid and gas formation and producing indol.

Collection of water samples.—Samples of water for bacteriological analysis should be collected in sterilised bottles of about eight ounces capacity. The analysis should be started within two or three hours of collection. As soon as water is stored in a bottle its conditions of equilibrium are upset and a change in the bacterial contents begins. Some bacteria multiply enormously, while others disappear, so that an entirely false picture of the flora of the water is obtained. If an immediate analysis is not possible, the bottle should be preserved in ice until the time of analysis. In collecting samples attention should also be paid to a few minor details :—

1. If it is taken from a tap the water should be allowed to run for about five minutes before the sample is collected.
2. If from a tank or river, the sample should be taken at a little distance away from the banks. A piece of string is attached to the neck of the bottle and sterilised, and only this sterilised string should be allowed to touch the water.
3. If from a well, the water may be obtained by lowering a sterile bottle weighted with lead into the well with a sterilised cord.

Two estimations are usually carried out to obtain an idea of the bacterial content of a drinking water. These estimations are :—

1. The enumeration of the number of bacteria present in the sample which are capable of growing in the agar medium at 37°C. This is commonly known as the 'Total Colony Count.'
2. The enumeration of a special group of organisms known as *B. coli*.

1. *The total colony count.*—A tube of the agar medium is taken, melted by heating in hot water for some minutes and then cooled to about 40°C. Before it solidifies, 1 c.c. of the water sample (or in the case of very polluted water 0·1 c.c. of the water sample) is dropped into the tube of melted and cooled agar medium, mixed by rotating the tube, and the mixture poured into a sterile petri dish and allowed to set. It is then incubated at 37°C, for about two to four days, when all the colonies appearing in the plate are counted using a hand lens. This gives the total number of bacteria of all kinds present in the sample. This method is of great help in studying the efficiency of different purification processes, such as sedimentation, filtration and chlorination.

2. *B. coli count or fæcal bacilli count.*—As the *B. coli* only exists normally in the intestine of men and animals, estimation of the number of colon bacilli present in a water is a valuable test as to the dangerous nature of any organic pollution, as these organisms if present are indicative of fæcal pollution. They are all *lactose fermentors*. The number of *B. coli* present in a sample is estimated by inoculating tubes of MacConkey's lactose broth with definite doses of water and observing the least quantity of water which produces the positive reaction in the tube after two days' incubation. Quantities of water used for inoculation are 20 c.c., 10 c.c., 5 c.c., 1 c.c., 0.1 c.c., and 0.01 c.c. When positive reaction is obtained in the medium it turns pink and gas bubbles are collected in the Durham tubes. A

rack is put up, three tubes receive 20 c.c. each, three tubes 5 c.c., three tubes 1 c.c., and three tubes 0.1 c.c. If none are fermented the water is said to be B. coli nil in 60 c.c.

The composition of MacConkey's broth is as follows:—Peptone, bile salt, lactose and neutral red. Peptone serves as food for bacteria, bile-salt inhibits the growth of saprophytic organisms, lactose serves to indicate the presence of B. coli, which alone ferments lactose; neutral red is an indicator to show the acidity resulting after the fermentation of lactose.

Identification of fæcal bacilli.—A positive reaction in MacConkey's broth is presumptive evidence of the presence of fæcal organisms therein. If confirmation is wanted a drop of broth which has fermented is plated out on MacConkey's solid medium so as to isolate and identify them in pure culture. Some types of B. coli are more resistant than others, and persist for long periods, even after the associated pathogenic organisms have perished. Their presence in a water only means that some fæcal matter had got access at some remote period and not recently enough to be dangerous. The varieties of the B. coli are separated into four groups by their reactions with saccharose and dulcite. The *B. cloacæ* and *B. neapolitanus* are known to be resistant organisms.

Isolation of fæcal bacilli.—Take a tube inoculated with 20 c.c. of water sample and showing a positive reaction after incubation. A loopful of the culture is taken and emulsified in sterile distilled water; a loopful of this is placed on MacConkey's agar plate and wiped with a sterile bent glass rod. After 18 hours' incubation separate colonies appear on the plate, some appearing pink and some white. The pink colonies are lactose fermentors and are fæcal organisms. A typical colony is selected and is picked out and inoculated with the fermentation tubes containing sugars such as saccharose, dulcite and adonite, and into peptone broth for the production of indol.

Interpretation of results.—The extreme delicacy of this method renders the interpretation of the results of a bacteriological analysis a task of considerable difficulty. The fullest possible information should be had about the water, and the surroundings from which it has come, noting particularly recent rainfall, if any. The object of the analysis may be:—

1. To ascertatn if any disease-producing organisms are present.
2. To ascertain if a filter is working satisfactorily.
3. To ascertain if pollution by sewage exists.

As regards the first, the presence of pathogenic organisms absolutely condemns the water for drinking purposes.

As regards the second, a good filtered water should show no *B. coli* in about 100 c.c. and a total bacterial count less than 100 per c.c.

As regards the third, it is difficult to lay down any arbitrary standards. Good deep well and spring water should show no *B. coli* in about 50 c.c. and a total count less than 100. Surface waters are poorest in quality during the rains, when they receive the washings of an indifferently preserved catchment area possibly including the excreta of men and animals. The *B. coli* may be present in 0.01 c.c. or about 100 to the cubic centimetre, and the total count may be several thousands per c.c. Gradually the various factors that make for self-purification in natural waters come into play, and a progressive improvement in the quality of the water is manifested on storage. In India sunlight and sedimentation might be said to be the most important of these. A well-sunned surface water should contain *B. coli* only in about 5 c.c. and a total count less than one thousand.

THE CALCUTTA MUNICIPAL ACT, 1923

BENGAL ACT, NO. III OF 1923

General duties of the municipal authorities in respect of the supply of water.

Sec. 215.—The Corporation shall provide (*a*) supply of filtered water within all parts of Calcutta, and (*b*) supply of unfiltered water within such parts of Calcutta as they may think fit, and shall cause such separate mains, pipes and taps to be laid and placed as may be necessary.

Sec. 216.—(1) The Corporation shall erect sufficient and convenient bathing platforms and pubilc stand-posts for the gratuitous supply of filtered water for bathing and other domestic purposes.

(2) All such bathing platforms and stand-posts shall be supplied with filtered water.

Sec. 219.—It shall be the duty of the Corporation to test the purity of the supply of filtered water once every week.

Sec. 220.—(1) Subject to certain provisions (section 215) filtered water shall be supplied for domestic purposes only.

(2) No person shall, without the written permission of the Corporation, use for other than domestic purposes filtered water supplied under this chapter for the said purposes.

Sec. 221.—(1) Unfiltered water shall be used for public purposes, such as,—(*a*) street washing; (*b*) flushing of municipal drains, public privies and urinals, gully pits and hackney-carriage stands: and (*c*) extinguishing fires; (*d*) flushing privies and urinals of private premises connected with the sewers; (*e*) for flushing drains, cleansing stables, cattle-sheds and cow-houses occupied by animals which are not kept for profit or hire.

(2) It shall not be used for domestic purposes.

Sec. 236.—(1) Whenever the Corporation has reason to believe that, as the result of defect in pipes or fittings connected with water-supply, the filtered water supply in any premises is wasted, they may, by written notice, require the owner or occupier of the premises within a period of four days after service of the notice to repair and make good the defects in the pipes, taps or fittings connected with the water-supply, so as to put a stop to such waste.

(2) If after the expiration of the said period of four days the Corporation have reason to believe that waste still continues, they may cut off the supply of filtered water to the said premises.

Sec. 237.—(1) The Corporation, may in their discretion, provide a water-meter and attach the same to the service pipe of any premises connected with the municipal filtered water-supply.

Sec. 246.—Whenever a supply of filtered and unfiltered water has been provided in any street, the Corporation may, by written notice, require the owner of any well situated in premises which are supplied from the mains, to fill it up with suitable materials.

Sec. 389.—(1) No person engaged in any trade or manufacture shall (*a*) wilfully cause or suffer to flow or be brought into any tank, reservoir, cistern, well, duct or other place for the storage or accumulation of water belonging to the Corporation, or into any drain or pipe communicating therewith, any washing or other substance produced in the course of such trade or manufacture; or

(*b*) wilfully do any act connected with any such trade or manufacture whereby the water in any such tank, reservoir, cistern, well, duct or other place is fouled or corrupted.

(2) The Corporation may, after giving not less than 2 hours' previous notice in writing to the owner or to the person who has the management or control of any works, pipes or conduits connected with any such manufacture or trade, lay open and examine the said works, pipes or conduits.

CHAPTER II

AIR AND VENTILATION

PURE air is necessary for healthy life, and perfect health can only be maintained when, in addition to other requirements, there is an abundant supply of pure air. Health and disease are in direct proportion to the purity or otherwise of the atmosphere. But it should be clearly understood that it is the physical and not the chemical changes which cause ill-effects. The discomforts of a confined atmosphere are due to the temperature, excess of watery vapour and lack of air movement, causing heat stagnation. Since moisture, stillness and warmth of the atmosphere are responsible for the ill-effects, efforts should be made not only to cool the air of crowded places, but also to cool the bodies of the people by setting the air in motion by means of fans. The strain on the heat regulating mechanism influences the heart and accelerates the pulse; more blood is sent to the skin where it circulates in far greater volume, so that less goes to the viscera and brain. In a hot, moist atmosphere the surface temperature rises, the cutaneous vessels dilate, veins become filled, the blood-pressure falls and the heart becomes fatigued from the extra work thrown on it. The increased percentage of CO_2 and the diminution of oxygen in ill-ventilated buildings have no effect *per se* on the incidence of respiratory diseases and higher death-rate. The temperature, moisture and windless atmosphere in these places diminish primarily the heat loss and secondarily the activity of the occupants, the total volume of air breathed, the oxygen taken and the food eaten. The whole metabolism is thus run on a lower plane, and the nervous system and tone of the body remain unstimulated by the monotonous, warm and motionless air. At the same time the number of the pathogenic bacteria and *droplet infection* are increased.

COMPOSITION OF AIR

Air is a mixture and not a chemical compound, and its composition is practically constant. This uniformity of composition is due to diffusion, constant movement by means of air currents and the reciprocal action of animals and plants on air.

The following is the approximate composition of the air:—

Oxygen	... ...	209.6 per 1000 volumes
Nitrogen	... ...	790.0 ,, ,, ,,
Carbonic acid	... ...	0.4 ,, ,, ,,

Watery vapour ...	...	varies with temperature
Ammonia ...	...	a trace
Organic matter ...	...	Variable.
Ozone ...	...	
Salts of sodium ...	...	
Other mineral substances ...		

Changes in the Atmosphere Due to Human Occupation

The chief changes in the atmosphere, physical and chemical, result from the following sources :—

1. Changes due to respiration.
2. Changes due to combustion.
3. Smoke.
4. Dust and bacteria.
5. Industrial impurities.

1. **Changes due to Respiration.**—A man usually respires about 18 times a minute, and at each respiration an adult gives out 22 cubic inches (500 c.c.) of air. In a mixed community 0.6 cubic feet of CO_2 per hour per head is added to the atmosphere. The proportion of gases in inspired and expired air per 100 parts is as follows :—

	Inspired air	Expired air
Oxygen	20.96	16.40
Nitrogen	79.00	79.19
Carbonic acid ...	0.04	4.41

It will thus be seen that the expired air contains 4 to 5 p.c. less oxygen and 4 p.c. more of CO_2. According to the chemical theory, the ill-effects produced in confined and crowded rooms have been attributed to (1) diminution of oxygen, (2) excess of CO_2, and (3) organic poison from the expired air. Very little attention was paid in the past to the variations of the temperature, movements of the air, and the amount of watery vapour contained in the atmosphere. Leonard Hill and others have shown that it is the physical and not the chemical properties that are responsible for the ill-effects in a closed and ill-ventilated room. As regards oxygen, it is necessary to remember that it forms about 20.93 p.c. of the outside atmosphere, and there is 14 to 15 p.c. in the depth of the lungs. In the most crowded rooms, it is rarely lessened by more than 1 per cent., that is, it is rarely as low as 19.93 per cent. of the air. This diminution exerts no physiological effect on the system. In fact as long as there is sufficient oxygen to change most of the hæmoglobin into oxyhæmoglobin in the lungs, there can arise no lack of oxygen. A person not exerting himself will not observe any effect until the oxygen has been reduced to 12 to 15 per cent., and consciousness will not be lost until the percentage sinks below 7 p.c. It is only in sewers, wells,

mines and hermetically sealed places, such as submarines, that serious want of oxygen or an excess of CO_2 is felt.

Carbonic acid.—It was formerly believed that the ill-effects noticed by breathing vitiated air of crowded rooms were due to the excess of CO_2 in the air. But it has been shown that even in a confined atmosphere the amount of CO_2 never rises to any great extent. In the worst ventilated theatres or schools it does not run over 0.5 p.c. or at the outside in most exceptional cases 1 p.c. Haldane and Priestley have shown that the excess of CO_2 in the atmosphere cannot enter the body, as the respiratory centre in response to the *p*H of the blood normally keeps the CO_2 contents of the pulmonary air constant, at least about 5 to 6 p.c. of the atmosphere. The effect of breathing 0.5 p.c. of CO_2 is an unnoticable increase in the ventilation of the lungs. The increased ventilation is so adjusted as to keep the concentration of CO_2 in the lungs at the normal of 5 to 6 per cent. During gentle exercise more CO_2 is produced, the pulmonary ventilation is increased, and the concentration of CO_2 in the lungs and blood is kept constant. Lehman found in a brewery 1.5 to 2.5 per cent. of CO_2 in the air of the fermentation rooms which was breathed by several workers for hours every day without any ill-effects. At each breath we breathe into our lungs the air in the nose and large air tubes (dead space air). Therefore about one-third of the air breathed by a resting man is dead space air. It is clear therefore that no one breathes in pure outside air, but air possibly contaminated by one-third to one-tenth with his own expired air. To rebreathe ones own breath is natural and inevitable, and to breathe some of the air exhaled by another person is also quite common. CO_2 therefore can be regarded as having nothing to do with the ill-effects of confined atmosphere.

Organic Poisons.—The belief in the existence of organic poisons exhaled by breath and skin cannot be substantiated. The foul odour of ill-ventilated and crowded rooms arises from perspiration and foul breath, *e.g.*, from carious teeth, dyspepsia and the decomposition of food particles in the mouth: from gases in the alimentary canal; from dirty clothes soiled with food and discharges from the body. Although odours by themselves may be harmless, good sanitary condition implies that houses, clothes and bodies of persons should be clean and free from offensive odours.

Watery Vapour.—This is always present in the atmosphere however dry it may be. The amount however varies with the temperature of the air and the amount of fluid present from which evaporation can take place. The humidity of a room also depends upon the number of persons occupying the room. About 10 oz. of water from the lungs and 20 to 30 ozs. from the skin is the average amount given off by each person in twenty-four hours. There is more

watery vapour in tropical atmospheres than in temperate and cold climates, more at sea than on land, more in summer than in winter, more at midday than in the morning and evening. The greater the temperature the greater is the amount of watery vapour which the air can take up. This is why water dries up so rapidly in hot weather. In humid atmosphere the lungs and the skin are unable to get rid of the watery vapour and thus a feeling of oppression and stuffiness is experienced. Excessive moisture in the air is an important factor in textile industries, and requires careful adjustment. The limit of humidity (moisture) of the air of an inhabited room should not exceed 75 p.c. A humidity beyond this combined with lack of air movement causes discomfort in a confined room producing heat stagnation, *i.e.*, partial abeyance of the normal bodily activity to lose heat by radiation and evaporation from the surface of the skin.

2. **Changes due to Combustion.**—Impurities due to combustion are chiefly derived from coal which is largely used as fuel. During combustion, coal gives off carbon monoxide and carbon dioxide in variable quantities, and also small quantities of sulphurous and sulphuric acids, carbon disulphide, sulphuretted hydrogen and moisture. About 1 p.c. is given off as soot or smoke, but in wasteful use of coal, when there is much unnecessary smoke, a much larger percentage is given off. There is also a corresponding decrease of oxygen from the air.

Artificial light always gives rise to impurities in the air. Coal gas and water gas are the popular illuminants. Coal gas is formed by the destructive distillation of coal and contains hydrogen, marsh gas, and carbon monoxide, sometimes ethylene, acetylene and CO_2. An ordinary gas burner consumes about 6 cubic ft. of gas and gives off about 3 cubic ft. of CO_2 per hour, *i.e.*, vitiates about 7200 cubic ft. of air, or to the extent which the breathing of three adults will do. Water gas is formed by passing a current of steam through heated fuel (coke or coal) in a fire-brick chamber, when the water is decomposed into H and O. It is a mixture of CO 25 to 50 p.c., with hydrogen. The oxygen is enriched subsequently with hydrocarbons.

Oils, chiefly paraffin oil, are also used as illuminants. When burnt they form CO_2 and water; an ordinary sperm candle of "one candle power" on complete combustion of its 120 grs. yields about 0.4 cubic ft. of CO_2, and almost the same amount of water. An ordinary paraffin lamp uses from about ·62 grs. of oil per hour per candle power, and produces 0.28 cubic ft. of CO_2. It follows that to produce a 16 candle power light, $\frac{1}{4}$ lb. of sperm candles, more than 2 oz. of paraffin, must be consumed per hour; the amount of CO_2 would be 6.4 and 4.5 cubic ft. respectively. Therefore vitiation of air would correspond to that caused by 11 adults in the

case of sperm candles and 7½ in the case of paraffin. It is evident therefore that all illuminants vitiate the atmosphere more or less. They raise the temperature, increase the moisture of the room, abstract oxygen from the air and add CO_2, CO, compounds of ammonia and particles of soot to the atmosphere.

Electricity is also largely used for purposes of illumination. This is the best source of light from a sanitary point of view, for, not being dependent on the oxygen of the air, it does not vitiate the atmosphere. The next best is the Welsbach incandescent gas burner. This gives off less CO_2 than any average oil lamp, and consumes less than half the amount of gas which an ordinary burner does.

3. **Smoke.**—Ordinary smoke consists of unburned carbon particles, hydrocarbons and other pyroligneous bodies, some poisonous gases, mineral acids, etc. It has been estimated that the damage to property caused by smoke is about five pounds per inhabitant per annum in England.

In England owing to rapid industrial development where coal is burnt more or less inefficiently in factories and houses, the amount of soot is too great. In a big Lancashire cotton town the amount in one year was 960 tons per square mile. In London itself domestic fire is responsible for most of the smoke. In Indian towns and in places like Calcutta, Bombay and other industrial towns the smoke is not only due to factories, ships, brickfields, etc., but largely to the use of coal for cooking purposes. In 1853 an Act to regulate the emission of black smoke was passed in England which was incorporated in the Public Health Act of 1875. The last Smoke Abatement Act (1926) removed the necessity for proving black smoke, and extended the powers of local authorities. These however failed to achieve the object and smoke is still an intolerable nuisance in England.

At one time pollution of the atmosphere with smoke assumed alarming proportions in Calcutta. But within recent years there has been a marked abatement of the nuisance. A few years ago (1906) it was noticed that for thirteen and half minutes in the hour there was dense black smoke in the air of Calcutta, in 1930 it was only 0.8 minute in the hour that the air was laden with smoke. It has been estimated that in Calcutta daily over fifty tons of soot escape into and pollute the atmosphere.

Few realise the extent of the damage to property caused by smoke, or the seriousness of the menace it holds out to the public health. A smoky atmosphere directly irritates the upper respiratory passages and increases the mortality from pulmonary diseases. Both smoke and soot predispose to pulmonary tuberculosis. A smoky atmosphere is a source of dirt, shuts out light and the ultra-violet rays of the sun, and prevents the entrance of fresh air. It corrodes the

mental and physical equipment of those who cannot escape from it to a purer atmosphere. Smoke also injures vegetation by choking up the stomata of the leaves and also by the action of the acid.

The report of the Bengal Smoke Nuisance Commission for 1930 shows that when the wind fails and the smoke is discharged into the stagnant air the respiratory deaths vault from 80 to 240 a week.

Smoke pollution is measured by drawing a known quantity of air through a disc of filter paper. It is so arranged that every five minutes a given volume of air is drawn through a fresh disc. The discoloration produced in the discs is measured against standards.

Abatement of smoke is not a very difficult task. It is in a large measure a social organisation, although the individual can help much. It only requires a careful study of the methods adopted in other countries to minimise the emission of soot. By the provision of properly proportioned furnaces, flues, chimneys and boilers much of the nuisance may be minimised. Emission of black smoke has to a great extent been remedied by the introduction of the mechanical boiler draught, but the chimneys still continue to discharge a great amount of dust and grit. Davidson and Co., Ld. of Belfast have introduced patent Flue Dust Collectors which have given very good results in many power stations in England; forty to a hundred pounds of dust per hour being collected by a single collector. Much of the household smoke is minimised by the use of electricity, gas stoves, or smokeless solid fuel with proper ventilation. This will require time till people begin to realise the harmful effects of acrid smoke so common in the kitchen.

4. **Dust and Bacteria.**—Dust forms an important impurity in the atmosphere of the tropics. It is composed of inorganic matter, organic matter and bacteria. Scales of epithelium; fibres of cotton, linen and wool; particles of hair; dried sputum and particles of excreta, etc., are found in inhabited but imperfectly ventilated rooms. Ordinary street dust contains soot, flue dust, silica, decaying leaves, manure, fragments of insects and their eggs, bacteria, dust from boots and clothes, etc. Street dust therefore contaminates food exposed for sale without proper protection.

The bacteria are carried about in the dust and the great source of aerial bacteria is the soil which is teeming with micro-organisms. On windy days and in dry weather, the air always contains more bacteria than at other times. The bacterial population of the air is also derived from all collections of dust and dirt from rooms and other inhabited places of any kind. Although the microbes present in the air are considerable in number they are as a rule harmless, but specific disease germs, *e.g.* tubercle, typhoid, etc., have

also been isolated from the air of crowded rooms. The number of bacteria present in the atmosphere depends upon local conditions. Few are found in the high mountains, at sea or in deserts. They are less in the open country and more in the air of big cities and crowded places. Leonard Hill found 750 bacteria per cubic metre in the staircase of a house before sweeping, and after ten minutes' brushing of the carpet there were 410,000. During normal breathing the expired air does not contain any bacteria, as the mucous membrane of the upper air passages acts as a strainer. But during coughing, sneezing, talking or other forced expiratory efforts, the fluid contents of the mouth are

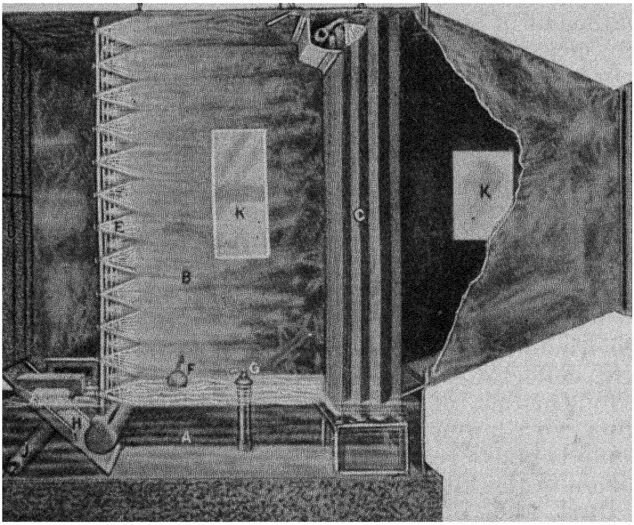

FIG. 18. STURTEVANT STANDARD AIR WASHER

A, Tank; B, Mist chamber; C, Eliminator plates; D, Metal screen; E, Atomising sprays; F, Ball valve; G, Overflow pipe; H, Copper gauze screen over suction pipe; J, Suction pipe to circulating pump; K, Inspection doors.

sprayed into the air in minute particles, and these "droplets" may contain the germs of any infection that may be present in the mouth or respiratory passages. Clean fresh air should be considered as important as clean water-supply, and the only way this is possible is by flooding rooms with abundant fresh outside air.

Just as rain washes the air, so dusty air can be cleaned by washing. This is done by passing the air through a chamber in which there are intersecting water sprays forming a curtain of fine droplets. Two-thirds of suspended particles, dust, bacteria and moulds can be removed by air washing. (Fig. 18).

5. **Industrial Impurities.**—A number of manufacturing impurities pollute the air. The chief ones are :—

(*a*) Silica dust from flint, granite, quartz, hard stone and mill-stone grit and other works.

(*b*) Lead fumes from various manufacturing processes.

(*c*) Dust from paper, cotton, jute, flax and flour mills.

(*d*) Hydrochloric acid gas from alkali works.

(*e*) Sulphur dioxide and sulphuric acid from copper smelting and bleaching works.

(*f*) Hydrogen sulphide from chemical works.

(*g*) Carbon monoxide, carbon dioxide, and sulphuretted hydrogen from brick-fields and cement works.

(*h*) Carbon monoxide from iron and copper smelting works.

(*i*) Organic matters from glue and gelatin factories.

(*j*) Zinc fumes from brass works.

(*k*) Arsenical fumes from metal works, where arsenic is used as an alloy.

(*l*) Phosphorus fumes from match factories.

(*m*) Carbon disulphide fumes from india-rubber works.

Sewer Air.—The air of sewers has long been regarded as dangerous and a likely source of infection in certain diseases, but it is only of late that much attention has been directed to its careful examination. The gaseous products of the decomposition of animal organic matter have been sought for, as also the micro-organisms of infectious diseases, *e.g.*, the bacillus of typhoid fever. The air of sewers plays very little part in the conveyance of typhoid fever and that the air of a well-ventilated sewer, as regards organic matter, carbonic acid, and micro-organisms differs little from outside air.

Diseases due to the Impurities of Air

A. **Effects of Dust and other Solid Impurities.**—Dust is a normal and important constituent of the air and its presence has a certain influence on the physical conditions of our environment. It is found everywhere, and though its presence is universal, its distribution is irregular. It exists in the form of organic dust in the lower strata but the inorganic particles are found everywhere. The organic dust consists of particles derived from the animal and vegetable kingdoms. The inorganic dust is derived mostly from soil and consists chiefly of silica, aluminium silicate, chalk, calcium phosphate, magnesia, iron, common salt, etc. Ordinary dust does not produce any harmful effects on the healthy respiratory mucous membrane. It is only when it is present in excess, or is of an irritating nature, or when it contains certain micro-organisms that its injurious effects become apparent. Dust free from micro-organisms, as for instance mineral dust, when breathed for a long period

causes certain affections of the lung tissue, *viz.*, potter's asthma and miner's anthracosis. Various industrial dusts produce different pathological conditions (see Occupational Hygiene). House dust is more injurious than the dust of the outside air as it too often contains pathogenic bacteria.

House dust is kept down by avoiding dry dusting and sweeping by the use of *vacuum cleaners.* and by efficient ventilation. Matting of floors always favours the harbouring of dust and should be avoided. Dust from outside is too often blown into the house. This is prevented by proper screening, windows and use of glass shutters. Street dust is very difficult, perhaps hopelessly impossible, to prevent in the tropics. Roads should be well constructed with a good surface. These require regular watering or oiling. Tarmacadam roads are an improvement and have considerably minimised dust nuisance.

B. **Effects of Gases and Volatile Effluvia :—**

(a) Effects of Gases.—See Occupational Hygiene.

(b) Effects of Effluvia.—

1. *Effluvia from Brick-fields.*—Bricks are burnt in two ways : in clamps and in kilns. *Clamp* (open air) *burning* is very offensive, for besides the ordinary products of combustion, certain pyroligneous matters are also formed, which have a very disagreeable smell and are injurious to health. Clamp burning should not, therefore, be permitted near inhabited areas. Sometimes dust-bin refuse is used to burn the bricks ; in such cases the partially burnt organic vapours are highly disagreeable. In *kiln* (enclosed) *burning*, bricks are burnt with the aid of coal only, and if the kilns are provided with flues the liability to nuisance is much less, as the products of combustion are more perfectly consumed.

2. *Effluvia from Offensive Trades.*—The effluvia arising from stables, cowsheds, tanneries, fat and tallow factories, gut scraping, bone boiling, paper making, etc., are all very offensive. (*See* Offensive Trades).

3. *Effects of Gas from Sewers and House Drains.*—The air of the main sewer is purer than the house drains. Sewer air does not show much difference in chemical composition from the ordinary outside air, but much depends upon the construction and ventilation of the main sewers. The sewer air should not be allowed to enter the house and pollute the atmosphere, but it is doubtful if it is responsible for any ill-effects, unless one is habitually subjected to its influence, when headache, febrile disturbances, anæmia and a tendency to sore-throat may occur.

KATA-THERMOMETER

Experiments in a confined chamber with or without the fan show that the thermometer fails to demonstrate the

conditions we feel. The ordinary thermometer shows its own temperature, the average temperature of the furniture, etc., but does not indicate the heat loss of the body, and gives no measure of the cooling and evaporative power of the environment on the skin which chiefly depends on air movement. While the thermometer is a static instrument indicating average temperature, the human body is a dynamic structure continually producing and losing heat, the temperature remaining sensibly constant. To secure a comfortable and healthy condition of the atmosphere in our rooms an instrument which indicates not the average temperature but the rate of cooling is wanted. The *kata-thermometer* contrived by Leonard Hill measures the rate of heat loss of a surface at approximately body temperature, 97.5° F. under variable atmospheric conditions. It consists of a large bulbed spirit thermometer having two marks upon it representing 95° to 100° F., with the corresponding mean centigrade figure, 36.5° C., placed between these. Two such instruments are generally used. One with bulb uncovered—the *dry* kata-thermometer—the other with bulb covered with a fine cotton mesh. The bulbs are immersed in water about 150° F. until the spirit rises into the small bulb at the top of the instrument. The excess of water is then shaken off the wet bulb and the other dried. The instruments are then suspended in the air and the time in seconds taken in cooling from 100° to 95° F. is noted with a stop watch. The same amount of heat will always be lost while it cools, but the rate at which it loses this heat will depend upon the external conditions, and so may be used as an indicator of them. In order that the rate of heat loss may be expressed in heat units (millicalories), the total heat loss, while cooling between 100° to 95° F., or corresponding centigrade figures, is determined for each instrument by the maker and is divided by the surface area of the kata expressed in sq. cm. The figure thus obtained is marked on the back of the stem, and is known as the "factor" or F. The factor divided by the number of seconds occupied in the five degree drop gives the rate of cooling expressed in millicalories per sq. cm. per second.

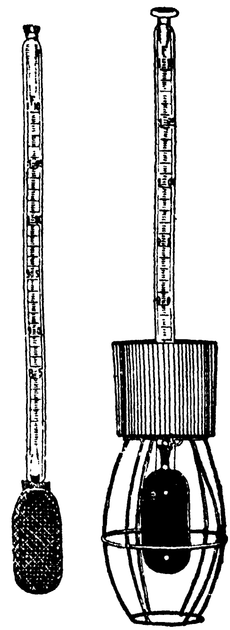

FIG. 19.—KATA-THERMOMETER

Example:	Factor of kata	=	500	
	Dry kata cooling time	=	60	seconds
	Wet kata cooling time	=	25	„

$$\text{Therefore dry kata cooling power} = \frac{500}{60} = 7.2$$

$$\text{Wet kata cooling power} = \frac{500}{25} = 20$$

The wet bulb gives the rate of cooling by radiation, convection and evaporation; the dry one gives the rate of cooling by radiation and convection. The dry kata cools four times as fast as the covered body of man. A high dry kata reading implies great cooling power and a low kata reading means the reverse. When DK is 5 the room will be too hot, and when DK is 15 it is too cold. At mean temperatures and humidities the wet kata cools three times as fast as the dry kata, *i.e.*, $WK = DK \times 3$. This however may not be correct when the temperature is hot. For the air conditions suited to heavy work the wet kata is the better guide. The difference between the dry and wet readings $(WK - DK)$ gives the cooling power due to evaporation only.

In the tropics, where the air temperature in the shade is above 95° F., the dry kata-thermometer cannot be used to measure cooling power, but when the atmospheric temperature is above 100° F. the kata-thermometer can be cooled and the heating power of the air measured by it. The wet kata is valuable in the tropics, cotton mills, etc., when sweating occurs.

A fresh, comfortable room has a dry kata cooling power of 5 to 6 and a wet kata cooling power of 16 to 18, *i.e.*, 6 or 18 millicalories of heat are lost per square cm. of body surface per second. Therefore this multiplied by 36 = per sq. metre per hour. If the room is perceptibly cool the figures will be 8 and 22 respectively; and if warm and stuffy, about 4 and 15.

VENTILATION

Ventilation means the removal or dilution of the atmosphere which has become stagnant, warm and moist through the vitiating processes described in the preceding pages by air which is drier, cooler and moving. This is sometimes called *internal ventilation*. But in the case of the general air space of towns, advantage is taken of the natural means of purification of air. This is done by making the streets broad, building houses moderately high, and not very close to one another, so as not to impede free circulation of air. This *external ventilation* is of primary importance, for upon the purity or otherwise of outside air depends the possibility of good internal ventilation. Efficient external ventilation may also be ensured by preventing impurities from entering the air, by watering the streets to lay the dust, by careful inspection of all drains and sewers, by transporting all offensive trades and occupations to special quarters, by the

speedy removal of street and other refuse, by such regulations as will prevent nuisance from smoke, and by keeping plenty of open spaces and parks.

The principal object of ventilation is the stimulating effect of moving air upon the skin, which depends largely upon the evaporating power of the air. Therefore ventilation to be satisfactory must conform to certain conditions, *viz.* it must supply pure air from without, it must keep the air within the room at a proper temperature and maintain a continuous circulation, and prevent stagnation of the body heat on the one hand and uncomfortable chilling and drying of the body on the other, the standard of which is given by the DK 6. It must also be able to remove gases, odours, bacteria, dust, etc., which contaminate the air, and dilute and remove the vitiation produced by combustion.

Amount of Air Required for Ventilation

The amount of air required for efficient ventilation varies and depends upon several factors, *viz.* the size of the room, the number of persons inhabiting the room and the heat stagnation produced by lack of air movement and excess of watery vapour.

1. **Amount of Air required for the Healthy.**—The average air contains 0.03 to 0.04 p.c. of CO_2, or 0.3 to 0.4 per 1000 volumes, and if a man breathes for an hour in a room of 1000 c. ft., the amount of CO_2 at the end of the hour, if no air is admitted or withdrawn in the meantime, will be 0.6+0.4 c. ft. or 1.0 p.c. One can detect with the sense of smell impurity in a room up to a certain point, and a man entering a room from the open air should not perceive any smell or stuffiness. After a series of observations De Chaumont came to the conclusion that when the CO_2 of the air of a room exceeded by more than 0.02 p.c. the percentage in the outside air, with the DK reading below 6 or thereabout, the feeling of stuffiness became perceptible to the senses. One may therefore assume that the presence of CO_2 beyond this limit is inconsistent with proper ventilation. A person at rest gives off 0.6 c.ft. of CO_2 per hour, and calculating on the above standard of purity, 3000 c. ft. of pure air must be supplied for each person per hour if satisfactory ventilation is to be maintained. Haldane and Hill however maintain that 1000 cubic feet of fresh air per head per hour is sufficient provided there is air movement. Although the percentage of CO_2 may be higher in the air of a room without producing any deleterious effect on the health, these figures enable us to form an idea regarding the ventilating arrangements. The greater the number of changes of the air in the room the better is the ventilation.

The amount of fresh air that should be delivered per hour

to an occupied room can be calculated by the following formula :—

$$\frac{e}{p} = d$$

Where $e = CO_2$ exhaled in an hour per head (0.6 cubic foot being taken as an average).

p = limit of respiratory CO_2 per cubic foot of air (*i.e.*, 0·02 c. ft. per 100 c. ft. or 0·0002 in 1 cubic ft.).

d = amount of fresh air available in cubic feet per head per hour.

Therefore $\frac{0.6}{0.0002} = 3000$, the number of cubic feet of air necessary for every individual of average weight per head per hour, CO_2 being taken as an indicator.

An adult male requires about 3000 cubic ft. per hour.

A child „ „ „ 2000 „ „ „

In a mixed community 3000 cubic ft. for each person are required.

Adequate floor space in dwellings for each person is an important factor for proper ventilation. Where the floor space is less it leads to over-crowding and consequently to defective ventilation, over-heating, excessive humidity and air stagnation. Limited floor space also favours the spread of *droplet infection* by shortening the path which the virus has to travel from one person to another. In ordinary houses the floor space for a single person should be 150 sq. ft., though it may be less for work-houses, *i.e.*, 65 to 80 sq. ft. For infectious disease hospital it should be 144 sq. ft. or 2000 cubic ft., for general hospital 100 sq. ft. or 1000 cubic ft. Average for boys and girls is 70 to 80 sq. ft. floor space or 700 to 900 cubic ft. of air space.

It should be noted that where the cubic space is large there is less need of frequently changing the air. For a single man occupying a room having an area of 100 cubic ft., the air should be changed thirty times per hour if 3000 cubic ft. of the air be given, a procedure which would cause a very disagreeable draught in cold weather. Whereas if the area of the room be 1000 cubic ft. the air requires to be changed only three times per hour for equal ventilation without creating any perceptible draught. By suitable arrangements of windows, etc., about half a dozen changes of the air of a room can be made without any draught being felt.

The authorised amounts of space alloted per head are as follows :—

Soldier ...	... 600 cubic ft.	
Dormitories of poor houses	300 „	(healthy person).
Army hospital wards	1200 cubic ft.	
Poor-law schools	360 cubic ft.	
Public elementary school	80 cubic ft.	

Registered lodging houses 400 cubic ft. occupied by day and night.
" " " 300 " occupied by night only.

2. **Amount of Air required for the Sick.**—For sick persons in hospitals, the amount of fresh air should exceed that required by the healthy by at least one-fourth. For instance, if 3000 cubic ft. be the average amount required in health, 3750 cubic ft. will be required in sickness per hour.

3. **Amount of Air required for Combustion.**—For an ordinary flat-flame gas burner which generates about 3 cubic ft. of CO_2 and consumes 6 cubic ft. of gas per hour, 1000 cubic ft. of air are needed for every cubic foot of CO_2 per hour. Therefore about 2250 cubic ft. of fresh air must be supplied per hour for each gas burner in a room.

4. **Amount of Fresh Air required for Animals.**—Animals require fresh air as much as men do. A horse or a cow ought to have about 10,000 to 20,000 cubic ft. of air per hour, in the ratio of 20 to 25 cubic ft. per hour for every pound of body weight.

Methods for Supplying the Required Amount of Fresh Air

Practical ventilation is an engineering problem, but the conditions of ventilation can never be the same, owing to the fact that the rooms and houses requiring ventilation vary greatly. No single system therefore, is applicable to all. But the fundamental principles are more or less the same.

The physical theory of ventilation may be stated in two propositions :—

(*a*) Given a "head of air," a continuous flow can be maintained through a room, the amount of air entering and leaving being equal.

(*b*) A "head of air," is produced by difference of pressure between the air within and the air without the room, and difference of pressure depends on temperature, aqueous vapour and diffusion.

Now the problem is how to produce such a head of air, or more appropriately how to provide each individual with approximately the quantity of air mentioned above.

Systems of Ventilation

In any system of ventilation the size and shape of the room are important factors requiring consideration. This, however, in dwellings, workshops, factories, schools and dormitories is an economic question. But in any case the room should be large enough to allow the air to be replaced two or three times an hour without any perceptible draught. Taking this as the standard, the minimum space is about

one-third the quantity of air required per hour, *i.e.*, from 700 to 1000 cubic ft. per person. The student should remember that air space by itself has little value unless the air is replaced by free circulation of fresh air.

All systems of ventilation may be classified into two main divisions depending upon the motive power which originates them. They are therefore classified into

A. Natural.

B. Artificial or Mechanical.

A. **Natural Ventilation.**—This depends upon three factors, *viz.*, (*a*) perflation and aspiration, (*b*) differences of temperature, and (*c*) diffusion of gases. Natural ventilation is considerably helped by building houses with sufficient open space and by having large numbers of windows opening direct into the outside air. *Cross ventilation* means free perflation between windows and other openings placed opposite to each other. Naturally cross ventilation becomes impossible in what are called *back to back* houses.

(a) Perflation and Aspiration.—Winds act either by perflation or by aspiration. Perflation means blowing through a room, when the doors and windows are open, as a natural result of air movement. This is the most rapid method of changing the air of a room and allowing fresh air to enter through other openings. When air is moving it drives the air before it, lessens the pressure arround it, and causes the surrounding air to move towards it by aspiration. Certain objections may be raised against winds as ventilating agents. They are:—

(i) The air may be very stagnant, and consequently ventilation becomes most imperfect.

(ii) The difficulty of regulating the velocity of the current, which by blowing very heavily against an exit shaft, may impede ventilation by obstructing the exit of the air.

The perflating power of the wind has in some systems of ventilation been used as a motive power, specially in the ventilation of holds and cabins of ships at sea. The wind is conducted below by means of tubes with cowls so arranged as to face the wind, the vitiated or used air escaping through a different opening. The aspirating power of the wind and the production of a head of air, when the wind blows over the top of a tube, can be secured by covering the air shafts with cowls, which while assisting up currents prevent down currents. No cowl, however, is effective save that it prevents foreign bodies, birds, rain, etc., from entering into the shaft. Some are rotatory and the disadvantage is that these are active when the wind is high and they are not needed, and are stationary and obstructive when it is calm and when they are wanted. In Indian towns where narrow lanes are abutted by high buildings ventilation in the lower rooms becomes necessarily imperfect. Movement of air in such rooms can

be best ensured by large metal pipes inserted through the roofs with funnel-shaped mouths turned towards the wind.

(b) *Effects of Differences of Temperature.*—Unequal temperature causes unequal weights in masses of air. If the air of a room be heated by fire or by the products of the respiration of men and animals or be made more or less moist, it tends to expand, and rises up or escapes through other openings. The outer colder air rushes in through every opening until the temperature of both outside and inside air becomes equal. But the incoming fresh air in its turn becomes heated and so a constant current is maintained. This is the basis of natural ventilation and on this principle depends the ventilation of rooms in cold countries where coal fires are used. In India when the air is very stagnant and the difference of temperature between the external and the internal air is small ventilation is more imperfect and the temperature is correspondingly increased.

(c) *Diffusion.*—Gases diffuse inversely as the square root of their densities. It has been shown by Pettenkofer and Roscoe that diffusion takes place in a room which is not air-tight, the air moving in and out and in every possible direction through bricks, chinks and crevices in doors and windows, etc. But under ordinary circumstances the diffusion, if there be any, is very small, and organic substances, which are not gaseous, but molecular, are not at all influenced by it. Therefore diffusion as a ventilating agent is inadequate.

Inlets and Outlets.—The openings through which ventilation is carried out are known as inlets and outlets. Inlets are intended for the entrance of pure air and the outlets for the escape of vitiated air.

In warm climates the doors and windows supply all the necessary ventilation, and in some instances pervious walls, as of bamboo matting allow free perflation without any harm whatever. In colder climates the doors and windows have to be closed and special arrangements must be made for inlets. The chimney serves the purpose of an outlet, but if insufficient other outlets must be provided.

(a) *Inlets.*—The chief point with regard to the inlet openings is that they should be placed in such positions that the air supplied be pure and not polluted before admission. In India where ventilation is carried out through doors and windows, these should, as far as possible, be on opposite sides of the room. Where special inlets are provided they should be near the floor, and from 24 to 48 square in. in area for each person. When the supply of air is cold, as in the hill stations, the current of air to which the body is exposed will be felt as a draught and might be intolerable ; but it may be allowed to enter without causing discomfort, provided its direction keeps it from striking directly on the persons

of the inmates. To secure this it should enter vertically through openings high enough to carry the stream into the upper atmosphere of the room where it would at once mix with warm air before its presence could be felt.

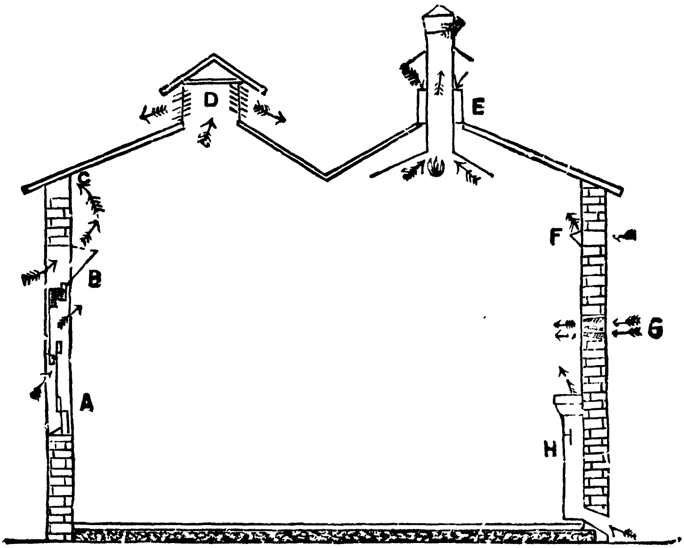

Fig. 20.—Sketch of Various Provisions for Ventilation.

A, Sash window. B, Hopper sash-light falling inwards. C, Ridge ventilation. D, Louvred outlets. E, McKinnell's ventilator. F, Sheringham's valve. G, Ellison's conical bricks. H, Tobin's tube. (After Parkes and Kenwood).

The common forms of inlets generally used in cold countries are :—

1. *Double Sash Window* with an air space between. Swinging windows are often employed as inlets especially in hospitals and schools.

2. *Louvres or ventilators* made on the principle of ventilation blinds. These can be opened or closed at will by a mechanical arrangement.

3. A hinge at the upper part of the window so that it can fall forward and act as a Sheringham's valve.

4. *Bricks perforated with conical holes* with the narrow end outside. The air passing through the narrow to the broad end is so distributed that it is not felt as a draught.

5. *Tobin's Tube.*—It is a short vertical shaft of metal plate or wood which leads up the wall from the floor level to a height of 5 or 6 ft. The lower end opens into the outer air through an air brick or an opening made in the wall ; the current of fresh air rises in a smooth stream through the

upper opening and it does not seem to change its direction until it has gone far above the opening.

6. *Sheringham's Valve.*—This is a flap door placed near the ceiling, and when opened it forms a wedge-shaped projection into the room and admits air through the open top in an upward direction.

7. *McKinnel's Ventilator* consists of an inner and outer tube, one encircling the other, the inner forming the outlet tube, and projecting beyond the outer both outwards and inwards. This is well adapted in hot countries when fixed on the roof of single storied buildings, *e.g.*, factories, theatres, etc.

(*b*) *Outlets.*—As a general principle the outlets should be placed opposite to the inlets. Respired air has a tendency to go upwards and outlet openings are best provided at the upper part of the room. Rooms with sloping roofs can have outlets in the form of *ridge-openings* along the entire top as in the case of Indian huts. In tropical climates windows are placed opposite to each other which act both as inlets and outlets.

The regulation of the ventilation openings is of some importance. In colder climates it is better for the windows to open at the top with a slope from below upwards and inwards, so that the cold air may be directed upwards and then sink by its own weight. In India the windows almost always open either outwards or inwards, and consequently the regulation of the direct force of the wind is not very easy. By keeping the venetians partly closed, and the inner glass shutters open, excess of light and wind may be prevented from entering the room.

B. **Artificial Ventilation.**—This may be carried out by (*a*) extraction of foul air, the fresh air entering to fill its place,—the *Vacuum System*; (*b*) by propelling fresh air,—the *Plenum System*; and (*c*) by a combination of both,—the *Balance System*. In the extraction system the motive power which acts at the end of the air current, may be a fan, a fire, or a furnace, whereas in the plenum system the motive power acts at the commencement of the air circuit, and must be some form of mechanical force. Of the two systems the propulsion method is more efficient because of the steadiness of its action. In order that both the systems should work efficiently, the room to be ventilated should conform to the conditions of a tight-fitting box except in the matter of inlets and outlets which should be provided. Open windows and doors disturb the continuity of the air current. This method of ventilation is suitable for large factories, specially those associated with dust, fumes and heat; schools; hotels; theatres; etc.

1. **Vacuum or Extraction System.**—

(*a*) *Fans.*—These are used for extraction as they are easily regulated and the amount of draught can be controlled.

Two types of fans, are generally used, *viz.* low-presure large volume fans and high-pressure fans. The low-pressure or ring type fans are suitable for handling volumes of air that offers little obstruction or resistance. These fans are mainly of the propeller type and are so fixed that they can draw air directly from a room where there are no obstructions. For efficient working of the propeller fans the following conditions are necessary.—

(*i*) abundant air supply to the room or place from which the fan is exhausting ;

(*ii*) free access of air on intake side ;

(*iii*) free discharge ;

(*iv*) suitable speed.

High-pressure or centrifugal fans are used to extract or propel air against resistance, as for instance in extraction systems where long and tortuous ducts are essential. They are therefore useful in furnaces, and in chemical works. In parts of very large halls where the air often stagnates, exhaust fans are used to waft the still air into general circulation. A fan 2 ft. in diameter makes 630 revolutions per minute and discharges 6000 cubic ft. of air.

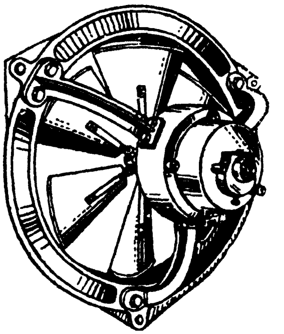

FIG. 21.—PROPELLER FAN WITH MOTOR.

(*b*) *Open fire with Flue.*—The principle underlying this system is that heat expands the volume of air, reduces the density, and thus causes an upward flow which in turn sets up a current in the room air. Ordinary fireplaces, chimneys and ventilating gas lights act in this way. The efficiency of ventilation depends upon the difference between the temperature inside the room and the temperature of the air outside. Mines are usually ventilated in this way by lighting a fire at the bottom of an upcast shaft which acts in the same way as a chimney does in a room. The ventilation is maintained by an intake shaft through which air is drawn down, and travels through all the workings and galleries of the mine before it escapes through the upcast or return shaft. The main point to remember in this system is that the fire should be put at the bottom of the upcast shaft and provision made at suitable points for free admission of pure air. By this method about 1000 to 2000 cubic ft. of air are supplied per head per hour, but in mines where fire damp is evolved, as much as 6000 cubic ft. of air per hour per man are given. This method is rather crude and expensive, and has been replaced by the use of exhaust fans at the head of the upcast shaft which suck the air up.

2. **Plenum or Propulsion System.**—In this system fresh air is driven into rooms by mechanical forces like revolving fans, steam jets or other appliances. The advantages of this system are that the source of air can be selected and the amount delivered can be regulated according to the requirements. But the air so treated loses its freshness and does not give that feeling of exhilaration one gets in ordinary fresh air.

(*a*) *Propulsion by fans*—For this purpose centrifugal fans with eight or more blades should be used. The ducts should be large, as with narrow tubes not only is the resistance increased but the speed of the current for an equal

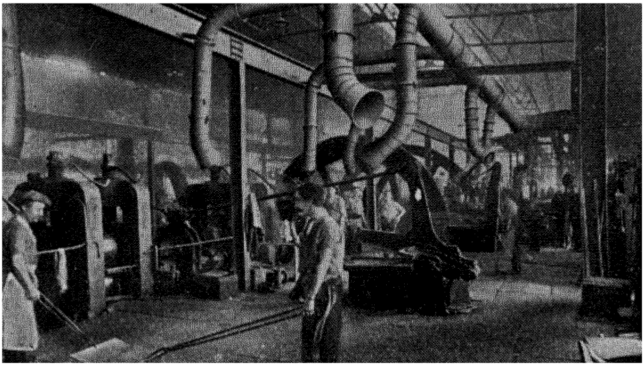

FIG. 22.—ROLLING MILL AT TINPLATE WORKS.
Note the Plenum System of ventilation supplying cold-air douche over the workers. (Courtesy of Sturtevant Engineering Co. Ld. London).

delivery has to be raised. It is always convenient to have the outlets trumpet shaped. This propulsion system of ventilation has the largest application in workshops and factories, and is used in operations attended with extreme heat as before furnaces so that cold air may be directly delivered over the workers. In very large workshops or public halls where there is difficulty of distributing air evenly, this system with a number of ducts uniformly distributed will ensure efficient ventilation.

(*b*) *Propulsion by Steam Jets.*—The force of the steam jet forms the motive power. Tubes passing from adjacent rooms converge into the chimney below the steam jet and the upward current extracts air from them. This plan is very suitable in factories where there is a spare supply of steam.

(*c*) *Propulsion by Pumps.*—This is used in some collieries for forcing in fresh or extracting foul air. It is seldom used for ventilating buildings.

3. **The Balance System.**—A combination of both the plenum and extraction systems is sometimes used specially for the ventilation of large halls with extensive sitting capacity. In the Houses of Parliament in London this system is in operation. The "cool room" of the Calcutta School of Tropical Medicine is also ventilated by the combined system.

The advantages of artificial methods of ventilation are the constancy and facility with which fresh air is supplied under all conditions, whereas natural ones though less costly are not under human control being subject to atmospheric conditions.

Purification of Air

It is of primary importance that the air we breathe should be as pure as possible. Under ordinary circumstances, the air is constantly purified by certain natural processes which are discussed below. But in large cities these natural processes are interfered with and purification of air is done by proper ventilation, or the air may be purified by washing by passing through a special air washer (*see* Fig. 18). This method is possible in artificial methods of ventilation. The natural processes of purification of air are :—

1. *Rain.*—This carries dissolved or suspended impurities to earth as is evidenced by an increase in the amount of ammonia, etc. Rain is in fact a mechanical purifier and washes the air.

2. *Plants.*—The green parts containing chlorophyll take in CO_2 from the air and assimilate carbon and give off oxygen to the atmosphere.

3. A few constituents that enter into the composition of the atmosphere help also to purify it. These are *oxygen* and *ozone*. Ozone is often used to remove foul odour and to destroy micro-organisms that may be present in the air.

Examination of Ventilation of a Room

The examination of ventilation of a room or a dwelling house to determine its fitness for human habitation is generally done by the following methods :—

1. Enter the room at the time of maximum contamination, *i.e.*, sometime after the people have been there, and note the first 'sense' impression, *i.e.*, whether the air is stuffy, smelly or otherwise offensive. This implies that the temperature of the air in the room is higher than that of the outside air, and that there is excessive humidity and stagnation of air.

2. Make a note of the number of occupants, nature and number of lights, open windows and other fresh air inlets. Ascertain the number of outlets. The rate of movement of

the air is determined by an anemometer and the amount of air entering the room is then calculated. These observations should be supplemented by the use of kata-thermometer. (*See* page 73).

Determination of the Amount of Cubic Space.—This is done by multiplying the length, breadth and height where the room is regular in shape. Where the rooms are irregular in form with angles, projections, etc., certain rules for measurements of the areas of circles, segments, triangles, etc., must be followed. It is seldom necessary to make deductions for chairs, tables and other furniture that occupy only a small space. But deductions should be made for persons living in the room and for solid furniture like cupboards, bedding, etc., which occupy a certain amount of space. Recesses containing air should also be measured and added to the amount of cubic space. The cubic contents of a room can be determined by any one of the following rules:—

Circumference of a circle = diameter (D) $\times$ 3.1416.
Area of a circle = $D^2 \times 0.7854$.
Area of an ellipse = product of the two diameters $\times$ 0.7854.
Circumference of an ellipse = half the sum of the two diameters $\times$ 3.1416.
Area of a square = square of one of the sides.
Area of a triangle = base $\times \frac{1}{2}$ height, or height $\times \frac{1}{2}$ base.
Area of a parallelogram = divide into two triangles by a diagonal, and take the sum of the areas of the two triangles.
Cubic capacity of a solid rectangle or a cube is found by multiplying three dimensions together.
Cubic capacity of a cylinder = area of base $\times$ height.
Cubic capacity of a cone or pyramid = Area of base $\times \frac{1}{3}$ height.
Cubic capicity of a dome = Area of base $\times \frac{2}{3}$ height.
Cubic capacity of a sphere = $D^3 \times 0.5236$.

The number of cubic feet of space per head is determined by dividing the total number of cubic feet (after necessary additions and deductions) by the number of persons occupying the room. The floor space per head is determined by dividing the total area of the floor by the number of persons.

Heating and Cooling

We have now to consider the problems pertaining to the heating and cooling of houses. This subject is intimately related to ventilation as difference of temperature is one of its causes. The heating of dwelling houses in India is restricted to certain hill stations, and even there only in winter. The opposite process of cooling the houses and atmosphere is more a necessity in India than that of heating. The means of producing heat are many, while the methods of keeping the rooms and the air cool though limited are being done with satisfactory results, but are rather expensive. A short description of both these methods is given below :—

I. **Distribution of heat.**—For the purposes of heating

houses and of ventilation, heat is commonly produced by the combustion of fuel, and is distributed by :—

(*a*) Conduction.
(*b*) Radiation.
(*c*) Convection.

(*a*) *Conduction.*—Solids are, as a rule, good conductors of heat, while liquids and gases are bad ones. Good conductors give off heat rapidly to the surrounding air and to articles in contact with them. This process is very slow as air is a bad conductor of heat.

(*b*) *Radiation.*—By this is meant the giving off of heat from hot bodies, such as open fireplaces, to colder ones through the air. During radiation, heat is transmitted in straight lines on all sides with equal intensity. The intensity of the radiant heat is in inverse ratio as the square of the distance. Thus if the heat at 1 foot distance from a fire be one, then at 4 feet it will be sixteen times less.

(*c*) *Convection.*—By this process heat is transmitted through gases and liquids. Convection depends upon a peculiar tendency of these bodies to expand with heat and thus to become lighter and rise upwards, their place being taken by colder and heavier portions, which in their turn become warm, expand and ascend, thus setting up a process of circulation of hot air in every part of the room.

The common methods of heating dwellings are :—

(*a*) Open fireplaces and grates.
(*b*) Closed fires or stoves.
(*c*) Pipes charged with hot air, hot water, or steam.

(*a*) *Open Fireplaces.*—This method is most extensively used in England and in the hill stations in India on account of the cheerfulness of the room and the efficient ventilation which it ensures.

(*b*) *Closed Fires or Stoves.*—In this method heat is obtained by burning fuel in a grate enclosed by a good conducting or absorbing material on all sides except below the bars. The air coming in contact with this heated surface becomes warmed and thereby heat is disseminated. These stoves are usually made of cast iron, bricks or tiles. Coal, coke, paraffin, etc., are burnt in these stoves.

Gas stoves are good for cooking and in cases where heat is required quickly and for a short time only. They should always have a flue, otherwise the products of combustion left in the room might affect the health of the occupants.

(*c*) *Heating by hot air, hot water, and steam* are also resorted to, but are not ordinarily adopted in India. Heating of rooms with hot air should not be done.

II. **Artificial Cooling of air.**—This is most important in India, and excepting the different hill stations, cooling of the atmosphere and of the rooms is specially called for during the summer months. This is generally done by preventing

direct radiation of the sun from entering the room, and by keeping the doors and windows closed during the day time. By this method the air inside the house is rendered much cooler than the air outside, and a circulation is thereby established. The outside air can be made cooler by passing it by means of Thermantidotes or fan-wheels, through wet *khus-khus* mats or *tatties* which will have the additional effect of acting as filters by removing all suspended impurities of the air. These are hung over doors and windows, and frequently wetted by sprinkling water on them. The evaporation of this water effectively cools the air of the room. Fans and punkahs though used as propellers also help to keep the room cool. By condensation and rarefaction of air certain changes in the temperature may be produced. By suitable arrangements of expansion cylinders, it is possible to have a supply of cold air, the temperature of which is much below that of the surrounding bodies. This method of cooling is utilised in refrigerating chambers in ships carrying meat. Experiments made at the Calcutta School of Tropical Medicine in building what is known as the "cool room" seem to hold great possibilities for controlling the temperature of the hot months. This room is kept at a temperature of 70° to 75° F. and is provided with inlets for

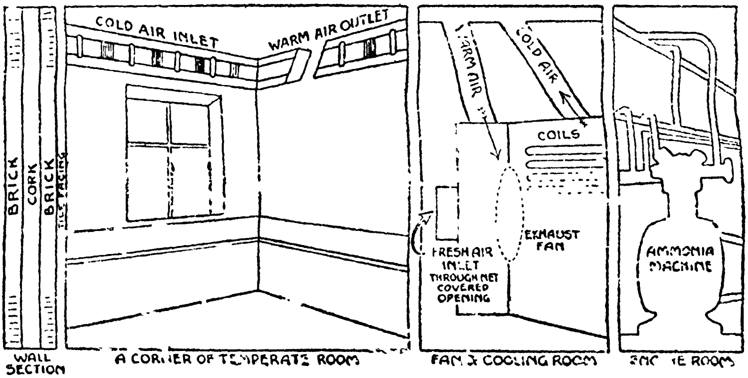

FIG. 23—ARTIFICIAL COOLING OF ROOM.

cold and outlets for warm air. The cold air passes through a pipe connecting the room with an adjoining room, the fan room, and the warm air goes out by another pipe which is discharged near the fan and passes over the coils into the cold air inlets leaving moisture behind. (*See* Fig. 23). The fan has a wire protected contrivance for the supply of fresh air from outside, free from dust. This also passes over the coils before reaching the cold air pipe. Next to the fan room is the ammonia machine room worked by a low speed motor. There is thus a constant circulation of air. Heated

air is being continually drawn off and returned again in the form of cool fresh air. There is no risk of chills, and by the provision of the fine netting over the inlets and outlets germs and mosquitoes are also eliminated.

The problem of air cooling in the tropics differs in principle according to the local conditions of weather and climate. Speaking generally in northern India, the air in the hot weather is excessively hot, over 100° F. but is dry ; a reduction of temperature alone will give comfort, even if accompanied by a rise in the relative humidity. The principle of cooling by evaporation is therefore made use of here—the hot dry air is passed through a thin layer of moisture and in passing through evaporates the water and so becomes cooler by the heat being taken from it to evaporate the water.

In hot moist climate like Bombay, Calcutta and Madras, the discomfort is produced both by high temperature and high humidity ; and the reduction of temperature alone would in itself be of little avail, as the absolute humidity would be the same and the relative humidity higher than at the original temperature. A reduction in both temperature and humidity is therefore necessary. It is to be remembered further that the feeling of comfort is the result of comparison with outside conditions, and it is not necessary to produce a constant set of conditions throughout the year. In Calcutta, for instance, during the hot weather and rains and autumn, it will be sufficient if the temperature of the cool room or hall is brought to 10° or 15° F. below the outside temperature and the relative humidity brought to below 60 to 65 p.c. Some installations with this end in view have been installed in Bombay and Calcutta, in theatres, business houses and legislative council chambers. The "air conditioning" as it is called is accomplished in the following manner :—Suppose the air outside is 90° F. with a relative humidity of 80 p.c. we wish to have the air inside at say 75° F. and a relative humidity of 60 p.c. The incoming air is drawn through a layer of fine water jets, the water of which has been reduced in temperature to 60° F. by a cooling plant. The air passing through these jets is brought to 60° F. and leaves saturated with moisture, the excess moisture representing 80 p.c. relative humidity at 90° F. being removed. Saturation at 60° F. equals 0.518 inch of mercury vapour tension. This air is then taken through ducts and delivered into the rooms. During its passage through the ducts it will become heated and will actually dissipate itself through the room at a temperature of about 75° F. It contains the same amount of moisture as it did at 60° F. and this represents at 75° F a relative humidity of 60 p.c. The air is drawn out at the *floor level* of the room or hall by means of outlets which lead it back to the cooling machine where it can be used again.

The Examination of Air

Collection of the Sample.—For examination purposes, air is best collected in large wide-mouthed glass jars of about 3 to 4 litres capacity, thoroughly cleaned and dried. The sample should be taken at the time when the atmosphere is at its highest degree of vitiation, as for example, in the case of school rooms when all the students have been in the class for some time. There are two methods of taking the sample:—

1. Take the jar filled with distilled water into the room, and empty it by turning it upside down. Dry it in the room and put the stopper in lightly or cover it up with an india-rubber cap so that no out-side air can enter.

2. Air may be blown in by bellows having a long nozzle, so that it may reach the bottom of the jar, and displace air from the very bottom. Whenever possible the examination should be done in the room itself.

The vessels should always bear a label on which the cubical capacity of the jar, the barometric pressure and the temperature at the time of the collection of the sample should be noted.

One with an acute sense of smell can readily detect the presence of carbon disulphide, sulphuretted hydrogen, coal gas, organic matter, etc. De Chaumont was the first to point out that the peculiar fetid smell perceived on entering an inhabited room from the outside was the result of the influence of atmospheric humidity on the organic matter. The impression on coming from the open air into an inhabited room should be recorded at once as the sense of smell gets dulled very soon. The smell also depends on the cleanliness or otherwise of the room and its occupants.

The examination of air should include the determination of (1) suspended matter, dust and bacteria; (2) organic matter; (3) carbonic acid; (4) carbon monoxide; (5) ammonia and watery vapour.

1. *Suspended Matter.*—The presence in the air of suspended matter is an indication of the kind of surroundings from which the air is taken. They include not only dust of animal and vegetable origin but various micro-organisms. The detection of these organisms is of importance, for which a bacteriological examination of the air is necessary. Suspended impurities are ascertained by aspirating the air slowly through a special apparatus. *Pouchet's Aeroscope*, over glass slides moistened with glycerin which intercepts the solid matter suspended in the air, and this matter is subsequently examined under a microscope.

To examine the micro-organisms, special cultures are made in or upon the surface of sterile nutrient media. For this purpose various methods are used. A rough and ready method is to expose in the air to be examined a lactose litmus agar in Petri dishes at varying intervals, and then to count the colonies which develop after a definite time. Special colonies, if desired, can be isolated and grown in sub-cultures and submitted to further examination. Frankland's method consists in aspirating a known volume of air through a plug of glass wool and finely powdered cane sugar in a tube 5-in. in length and ¼-in. in diameter. All the samples having been taken a file-mark is made across the center of each tube, which is then broken in half and the plug of glass wool and sugar which retain all the micro-organisms is pushed by a sterile wire into a sterile flask of 150 c.c. capacity. In this 10 to 15 c.c. of liquefied sterile nutrient gelatin are introduced, when the sugar dissolves, the glass wool becomes distintegrated, and a roll culture is made on the walls of the flask, which is incubated at 22° C. and the colonies are counted when they have developed.

2. *Organic Matter.*—This is estimated by aspirating a definite quantity of air through a freshly prepared solution of potassium permanganate of known strength. The undecomposed permanganate

is determined by oxalic acid. The result is obtained by calculating the number of cubic feet of air required to decolorise 0.001 grm. of potassium permanganate in solution. The test, however, is not very satisfactory, as it gives no indication of the nature of the organic matter, whether of animal or of vegetable origin. Moreover, nitrous, sulphurous and other acids present in the air give the same reaction.

3. *Carbonic Acid.*—The presence of carbonic acid in the air is not injurious to health, but being a product of combustion and respiration its estimation gives an idea regarding the degree of pollution of the air. Many methods have been devised for the estimation of CO_2 in the atmosphere.

Pettenkofer's Method.—This method depends on the fact that an alkaline medium like lime water or baryta water absorbs CO_2, the alkalinity being thus diminished. Therefore the difference in the degree of alkalinity before and after the experiment gives an index of the amount of CO_2.

Technique.—Add 50 c.c. of clear and fresh baryta water to the sample of air in a Winchester quart and replace the stopper. Allow it to stand for some time with occasional shaking to allow the CO_2 to mix with the baryta water to form barium carbonate. The alkalinity of baryta is determined by a standard solution of oxalic acid. 1 c.c. of which is equivalent to 0.5 c.c. of CO_2. Phenolphthalein is used as an indicator, the colour disappearing on neutralisation.

Haldane's Method.—This is the most practical and convenient method and gives sufficient accurate results. Haldane uses ordinary gas analysis apparatus and determines the loss of volume in the sample before and after absorption of the CO_2 by caustic potash solution. A glass burette with a wide ungraduated portion, and a narrow portion graduated in division of $\frac{1}{10,000}$th part of the capacity of the burette is employed. This is enclosed in a water jacket, and a control tube of approximately the same size as the gas burette is used to correct the variations of temperature. The diminution of volume as shown by the difference between the two readings, *i.e.*, before and after absorption, by measuring the level of the potash solution in the narrow bore tubing of the absorption pipette, gives the result in volumes per 10,000.

4. *Carbon Monoxide.*—(*a*) Solution of blood is mixed with the sample of air to saturation when it forms a yellow solution, if the air contains carbon monoxide the colour becomes pink. (*b*) Aspirate air through diluted defibrinated blood and examine under a spectroscope. If carbon monoxide is present two well-marked bands in yellow and green part between lines D and E will be seen. On the addition of ammonium sulphide no change will be found in the air containing CO but in oxyhæmoglobin two lines will be replaced by a single broad line showing the spectrum of hæmoglobin.

5. *Ammonia and Watery Vapour.*—Ammonia is estimated by drawing the air through distilled water previously tested as to its freedom from ammonia and then examining the water according to Nessler's test.

Watery vapour is determined by various forms of the hygrometer. For a description of these see Chapter on "Climate and Meteorology."

CHAPTER III

OCCUPATIONAL HYGIENE AND OFFENSIVE TRADES

WITHIN recent years industrial hygiene has assumed an important position in preventive medicine owing to the enormous progress made with regard to different industries. This deals with the health, the welfare, and the human rights of the vast majority of the population. New problems have been introduced largely through the development of new industries and the invention of new processes. Thus, we have the mining industries where the miner is compelled to work underground, and where the mortality from accidents and diseases of the lungs is high. Coal miner's phthisis and anthracosis are well-known diseases. In jute and cotton mills, the workers are exposed to dusty occupation for several hours, and are likely to suffer from chronic lung troubles. Liability to plumbism in the manufacture of white lead; necrosis of the jaw in the manufacture of matches; production of epitheliomatous ulceration and cancer of the skin in those handling pitch, tar and oil; and the risk of life and limb to those working in mills, railways, mines, etc.; the dangers of inhaling irritating fumes from different suspended impurities, gases and effluvia (*see* page 72); the risk of infection from anthrax among persons handling wool, horse hair, hides and skin; and finally the liability to hookworm infection—these are all typical occupational diseases. Apart from all these, there are other conditions, though not directly related to industries, which seriously affect the health of the workers. These arise from poor ventilation, lack of cleanliness, over-crowding, faulty lighting arrangements, etc.

In order therefore to improve the sanitary condition of the people working in different industries, certain rules have to be followed for the welfare of the workmen. The following require careful consideration:—

1. *Hours of Work.*—These require to be regulated according to the nature of the work, the physical exertion required, and the amount of nervous tension. Special consideration should be shown to women and children. Pregnant women should not work for several weeks before and after confinement. Boys under eighteen years should not be engaged for works involving danger to health from irritating dust or poisonous fumes. The Royal Commission of Labour in India (1931) fixed the weekly working hours for factories to 54 and the daily limit to 10. For women the rest period should

include the hours between 10 p.m. to 5 a.m., and for children the work should not exceed $7\frac{1}{2}$ hours and the rest period should include 7 p.m. to 5-30 a.m.

2. *Periodical Inspection.*—This is necessary for the protection of workmen. During these inspections, the conditions under which the work is carried on, and those under which the workmen live outside the working hours, require very careful supervision. Ventilation, dust, cleanliness, gases, vapours, heat, dampness, light, overcrowding, drinking water, washing facilities, latrines, sanitary arrangements, hours of work and rest, etc., all require to be investigated. Periodical medical examination, whereby minor ailments may be recognised and treated, and the testing of workers' fitness after a few years of factory service, would, by the elimination of the unfit, tend to maintain industrial efficiency.

3. *Accidents.*—Industrial accidents still exact too high a toll of human life. These are common in those working in railways, mines and factories, and with proper care it is possible to reduce these to a minimum. Certain special injuries and diseases are common to workmen, for instance, spinal curvature due to faulty posture ; varicose veins from long standing ; injuries to the eye from fragments of stone or metals ; impairment of vision from faulty lighting, or eye strain ; etc. Since many accidents are preventable, they ought to be prevented. The fencing of exposed portions of the machinery, the cleaning of machines after they have ceased running for the day, the protection ot the lifts, better illumination of the work room, passages and stairs, and instructions given to the workers on the dangers incidental to the work, will considerably lessen the number of casualties.

4. *Lighting.*—Whatever the nature of the work, there must be sufficient light in every factory to enable the workers to see clearly and without any effort. It is of course clear that the amount of illumination necessary will vary with the nature and character of the work, but there must be a limit which should not be exceeded, since defective lighting in any workshop or factory often increases the risk of accidents. The lighting of coal mines is of special importance. It has been definitely established that defective illumination is the major factor in the causation of miner's nystagmus. Whenever possible, natural lighting should be preferred, therefore all workshops should be made to face east and west so that the sun might enter the rooms. The light available should be well distributed, and if the walls are periodically white-washed it will not only help to keep the rooms bright but will also help proper diffusion of light. When artificial lights are used, preference should be given to electric lighting, as this causes no vitiation of the atmosphere. Indirect illumination is the best, specially when reflected from the ceiling. When low bright lights are used they should be

protected with a shade or reflector so that no beams from the lamp can fall directly on the eye of the worker when looking either at his work or horizontally across the room. Insufficient lighting besides increasing the incidence of accidents, damages the eye sight and leads to general insanitary conditions, as accumulation of dirt and other defects may pass unnoticed.

5. *Ventilation.*—Efficient ventilation is essential in all factories and workshops. Badly ventilated workshops lower the vitality, increase susceptibility to disease and interfere with the mental and physical efficiency of the workers. Industrial fatigue is partly due to air stagnation and polluted atmosphere. Natural ventilation, except in small workshops and factories, is not always possible. In every case arrangement should be made for cross ventilation. In single-storied workshops ridge ventilation or sloping central ridge roof are quite efficient. In large factories, specially those associated with dust, fumes or heat, mechanical systems are necessary. These are either extraction or exhaust ventilation, or plenum or propulsion, or a combination of both. A supply of cool air to places where hot work is carried on, *e.g.* the furnace department of gas works or tin plate works, where the workers are subjected to very high temperature, adds greatly to their comfort, health and efficiency. This is best done by an efficient plenum system of ventilation whereby a cold douche of air can be delivered over the heads of the workers (Fig. 22).

6. *Cleanliness.*—Cleanliness of factories and workshops and their surroundings should be maintained. The walls and ceiling require periodical lime-washing or painting, and every attempt should be made to keep away effluvia and dust. This is more important in dusty trades (*see* p. 104), specially where the dust is poisonous or otherwise dangerous. In textile mills dealing with jute, wool, flax and silk, where large quantity of dust and waste material are thrown during the various manufacturing processes, these require careful handling for the health and efficiency of the workers. To eliminate dust and to keep the different machinery in proper order, the use of vacuum cleaners and installation of dust removing plant give satisfactory results. Cleanliness of the skin is an important matter for coal miners to prevent getting beat-knee and beat-elbow which are due to septic infections of the skin at sites which have become irritated during work. Provisions for water and places for washing should be obligatory for workers in dusty processes.

7. *Humidity.*—It is usually thought that the health of the workers in the wet or humid sheds is worse than of those working in the dry sheds. When humidity is present heat is far more difficult to withstand, as the body cannot then cool by sweating. But Greenwood in a recent investigation

has thrown some doubt on this, and his results would seem to show that the temperature is a more important factor than humidity. A recent Commission in India recommended that when artificial humidification was used in cotton factories in India the wet kata reading should not be below eleven.

In the year 1911 the Indian Factories Act (Act XII of 1911) was passed to improve the hygienic conditions under which the people work, and also to take measures to prevent diseases incidental to particular occupations. By this Act the Local Governments can appoint inspectors with powers to regulate hours of work and to recommend sanitary measures with regard to ventilation, lighting, water-supply, latrine and urinal accommodation and general cleanliness, provision for means of escape in case of fire, precautions against fire and accidents, as would be conducive to the health and welfare of the factory hands. The Royal Commission of Labour (1931) recommended that every factory should be compelled to maintain separate and sufficient number of latrine accommodation for males and females, and adequate staff to keep them clean. They further observed that creches should be provided for children up to the age of 6 years when considerable number of women are employed. This should be statutory for places employing 250 women or more.

Industrial Poisons

Lead.—Lead is a cumulative poison and being an important article of commerce it is a most common and insidious industrial poison. It gains entrance into the system by (*a*) swallowing minute particles when it is converted in the stomach by the hydrochloric acid of the gastric juice into a chloride, which is readily soluble ; (*b*) inhaling dust and fumes of lead when in a molten state ; and (*c*) absorption from the skin in handling lead, rather rare. Chronic poisoning originates from the slow absorption and retention of minute quantities of the metal. Workers in lead factories and those who constantly handle lead are very prone to poisoning as they generally contaminate their food with their unwashed hands. Trades and occupations in which lead poisoning is likely to arise are:—*Lead mining* and smelting; manufacture of red, white or carbonate of lead ; painters and colour grinders ; manufacture of lead pipes and plumbers' supplies, such as solder, etc.; shot manufacture ; type founderies ; coloured glass manufacture ; various textile trades where colouring matter containing lead salts are used ; pottery manufacture during painting and decorating or gilding ; and manufacture of storage batteries where lead grids or perforated plates are used. *Tetraethyl* lead added to ordinary petrol gives rise to highly toxic and poisonous fumes in the process of combustion. It is readily absorbed by the

lungs and skin giving rise to symptoms of acute and subacute lead poisoning.

The preventive measures should consist of cleanliness of the hands and finger nails, frequent bathing, the use of separate clothing while at work, thorough washing of the hands and rinsing the mouth before eating, and avoidance of any food in the workroom or where there is suspicion of lead in the air. Good nutritious food with plenty of milk (because of its high calcium content) and avoidance of all excesses, specially alcohol is essential. The workshop should be kept clean, well-ventilated, and free from dust by wet cleansing of floor, etc. Arrangements should be made for rapid and complete collection of all fumes and dust by the installation of suitable exhaust ventilator. Handling of poisonous materials should be reduced to a minimum by substitution of mechanical methods.

Mercury.—Persons engaged in the preparation of vermilion, barometers, thermometers, and workers in factories where mercurial salts are either prepared or handled, expose themselves to the poisonous effects of the metal. The usual channels of entrance are the same as those of lead and arsenic.

The sanitary precautions to be observed are similar to those mentioned in the case of lead. Workmen should be provided with overcoats. Special attention should be paid to the proper care of the mouth and teeth, and all carious teeth should either be removed or filled. Metallic mercury vaporises even at the ordinary temperature and may produce poisonous effects. It should therefore be kept covered to lessen the emanations as far as possible. The floors should be so constructed as to render the collection of all spilt mercury easy.

The following precautions should be adopted to prevent mercurial poisoning:—

1. The adoption of exhaust ventilation wherever dust and fumes are evolved.

2. To carry on all work in rooms at a temperature below 60° F. so as to reduce the danger of volatilization to a minimum.

3. To have workrooms with smooth asphalt floors; all benches, tables, etc., having enamelled iron tops.

4. Taking such measures as will prevent spilling of mercury.

5. Workers provided with respirators and overalls.

Phosphorus.—It is used chiefly in the manufacture of matches, and poisoning occurs only in those who expose themselves to its fumes. They suffer from necrosis of the jaw, or from a characteristic cachectic condition with anæmia, dyspepsia, albuminuria and bronchitis. *Fragilitas ossium* is also found in those working in phosphorus.

Precautions.—The use of yellow phosphorus, which is more poisonous, is now forbidden by law, and is substituted by sesquisulphide of phosphorus which is harmless. The safety match contains no phosphorus and is harmless. The "strike anywhere" matches may be made with non-poisonous sesquisulphide of phosphorus instead of the poisonous white phosphorus. The fumes of white and yellow phosphorus are rich in oxides and are readily absorbed into the human system.

Special care should be taken of the teeth, and persons with carious teeth are particularly susceptible to the action of phosphorus. Rigid personal cleanliness should be observed and washing out the mouth with alkaline solutions encouraged. The work should be carried out in large, well-ventilated rooms, and if possible in the open air. The inhalation of turpentine with a view to oxidise phosphorus is also recommended.

4. **Arsenic.**—Poisoning occurs amongst those who handle arsenical pigments; inhale arsenical dust from wall-papers; are engaged in the making or manufacture of Paris green, Scheeles green, and articles coloured with arsenical dyes, *e.g.*, artificial flowers; or amongst those who prepare the skins of animals for stuffing. Arsenic may enter the system by the same routes as lead. Poisoning may occur (1) from the dust of salts of arsenic, by inhalation and contact; and (2) from arseniuretted hydrogen gas. The possibility of arsenical poisoning from food-stuff should be kept in mind. An outbreak occurred in Manchester from contaminated beer. The arsenic was derived from glucose and invert sugar used in the manufacture of beer. Glucose is prepared from starch, and invert sugar from cane sugar by the aid of sulphuric acid which may contain arsenic. The salts act as local irritants specially around the nose, mouth, armpits, etc. The symptoms of irritation are seen on the skin in the form of acneform or eczematous eruption; on the mucous membrane of the air passages and eyes, causing conjunctivitis and œdema of the eyelids, running of the nose, dry throat; and gastro-intestinal symptoms producing great thirst, loss of appetite, colic, vomiting and diarrhœa. In some cases the nervous system suffers, causing neuritis and paralysis of the peripheral nerves.

The sanitary precautions necessary are similar to those described under lead poisoning. The substitution of harmless colours in place of arsenical pigments would do much to prevent the harmful effects.

Industrial Gases and Fumes

In many industries the fumes and smoke given off are dangerous to the workers and require serious attention. Arrangement should therefore be made for their removal and

to prevent any from escaping into the building and thus acting on the health of the workers. This is specially necessary in chemical industries and metal workers. Provision should be made for suitable hoods so that the fumes are led through them into an exhausting system which is served at the extractor end by a centrifugal fan.

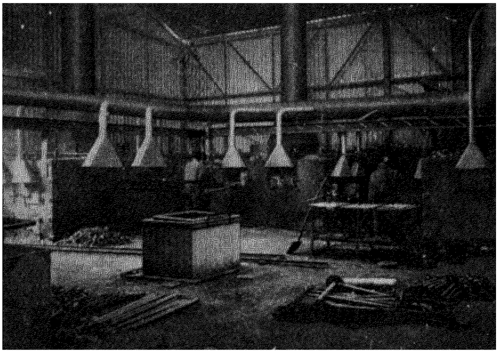

FIG. 24. METHODS OF REMOVAL OF SMOKE AND FUMES.
(Courtesy of Sturtevant Engineering Co., Ld., London).

1. *Arseniuretted Hydrogen.* AsH_3.—This gas is found in chemical and galvanising works. Cases of poisoning occur from the use of commercial acids derived from arsenical pyrites, or by the action of acids on metals containing arsenic. The inhalation of this gas produces symptoms of toxic jaundice and haemolysis.

2. *Carbon Monoxide.* CO.—It is a colourless gas without any taste or smell, and as it is formed at lower temperatures than CO_2, it is easily produced whenever the air supply is deficient. The contact of a gas flame with cold metals, or a cold plate reduces the temperature to that which helps a continuous supply of CO. Coal gas contains 6 p.c. and water gas 30 p.c. of CO and are dangerous. Turning a gas flame of a cooking stove too high means a good supply of CO. It is extensively found in various industries and is the result of incomplete combustion of carbonaceous material. It is also formed by the deoxidation of CO_2 and in the "after-damp" of mine explosions (*See* page 100). It is given off from the blast furnaces of iron industries. Cases of poisoning also occur from burning of any form of fuel, *e.g.* coal, wood, charcoal, etc., without sufficient provision for the products of combustion to escape. Accidental cases of poisoning are of very frequent occurrence specially because the gas has no odour or irritant action. It has greater affinity for haemoglobin than oxygen; and forms a stable compound with

hæmoglobin replacing to a large extent the loosely combined oxygen. It thus paralyses the action of the blood corpuscles to act as an oxygen carrier. The effects are therefore due to oxygen deprivation which deranges the normal metabolism of body cells. Breathing small quantities of CO for long periods may produce deleterious effect on the health causing anæmia, or a form of mental derangement leading to nervous breakdown. The after effects are varied in character: nausea, headache, symptoms of heart trouble, hæmorrhage into the central nervous system, neuritis and attacks of pneumonia may appear. An early symptom of chronic poisoning is fainting and loss of power on exertion, and headache. Haldane has shown that the presence of 0.05 p.c. of carbon monoxide in the air produces toxic symptoms in man. When the air contains 0.08 p.c. of CO the hæmoglobin becomes half saturated, and the presence of 0.1 p.c. causes symptoms of headache and lethargy to appear within one hour. Accidental deaths from CO poisoning is not uncommon in private houses during cold weather when people sleep with all doors and windows closed and keeping an oil lamp or a charcoal fire burning within the room.

Recently the danger of CO poisoning in air craft and motor cars has been emphasised, which arises from imperfect combustion of fuel. The detection of CO either in the blood of pilots or in the air of cockpits led to modification of the exhaust manifolds, and all new planes are tested and CO eliminated before they are accepted by the U.S. Navy. The danger of CO poisoning from motor cars is less in open streets where the gas is freely diluted, but in traffic tunnels where the CO concentration may be high when the traffic is held up the danger is great. The danger may arise in closed garages with the engines running, when the concentration of CO may rise rapidly. Therefore garages should be properly ventilated and care should be taken that discharging gases do not leak into the interior of the cars.

3. *Sulphuretted Hydrogen, H_2S.*—This gas has a peculiar smell of decomposed eggs, and is dangerous to health even in 0.2 to 0.4 p.c. It is sometimes found in old sewers, and in mines as the product of decomposition of iron pyrites. In minor degrees of poisoning it causes headache, gastric disturbances, nausea, inflammation of the conjunctiva and cough. When inhaled for long periods it causes convulsion, paralysis, coma and death.

4. *Chlorine, Cl.*—This gas is evolved in the manufacture of chlorine, chloride of lime, chlorates, in bleaching processes, paper mills and in the manufacture of chlorine disinfecting agents. It has a strong penetrating odour and causes suffocation. In acute poisoning it causes lachrymation, coryza, cough and dyspnœa. There may be bronchial catarrh and pneumonia. Chronic poisoning caused by inhalation of

minute quantities gives rise to anaemia, gastric disturbances, headache, and the gradual decay of health with emaciation.

5. *Ammonia, NH_3.*—It has a sharp penetrating odour and is evolved in the manufacture of ammonia, sal ammoniac in the silvering of mirrors, tin plating, in connection with refrigerating plants, and in the manufacture of ice. Prolonged inhalation causes chronic bronchial catarrh, irritation of the mucous membrane of the respiratory tract, inflammation of the conjunctiva, salivation, paroxysmal cough with expectoration of thick viscid mucus, etc.

6. *Carbon Disulphide. CS_2.*—This is used chiefly in the rubber industries and one part in a million of air is said to be toxic, and breathing of one and a half parts per million produces serious symptoms. It is also used in the manufacture of waterproofs, as a solvent of fats, and in the preparation of cellulose for artificial silk, etc. Acute poisoning is rare. Chronic poisoning may occur after prolonged exposure. Headache, nausea and dizziness are the only symptoms, these are followed by cold in the extremities; or pain, cramps, numbness or anaesthesia in different parts of the body. There may be dimness of vision with weakness, tremor or larger involuntary movements. Digestion may be impaired and there may be colic, diarrhœa or constipation. Patient becomes irritable and depressed. Memory becomes weak, extremities cyanotic and the knee jerk exaggerated. Pathological changes are atrophy and fatty degeneration of muscles and connective tissue. It acts on the blood and causes hæmolysis.

Prevention.—Use less poisonous solvent, *e.g.* carbon tetrachloride. Efficient ventilation is of the highest importance. The gas is heavier than air, therefore exhaust pipes should be placed on the floor. Mechanical and closed methods of handling should be adopted as far as possible. The gas is inflammable and no naked lights should be used.

Coal Mines

According to the census of 1921, about 181,594 persons were employed in the different coal mines in Bengal, Bihar, and Orissa. Of these about 125,000 persons work within the jurisdiction of the Asansol Mines Board of Health in 202 collieries. The miners work more or less in darkness, and as a result of their peculiar attitude during work suffer from "Beat elbow" and "Beat knee". Bursitis follows which subsequently becomes the site of septic cellulitis. The installation of pithead baths will do much to prevent these septic troubles. The unnatural conditions under which the miners have to work underground, more or less in darkness, and under imperfect ventilation, contribute to make their occupation a risky one. Owing to defective illumination a peculiar form of eye trouble, *miner's nystagmus* develops among the

workers. Therefore mines require proper illumination. The ideal illumination is by the cap lamp; where this is not possible, a hand lamp of not less than 4 candle power with frosted prismatic glass with a slight greenish tinge should be introduced which will prevent pillar shadows and diminish glare. Plain glass electric lamps should not be used underground owing to the marked glare. But the diseases from which the miners in Bengal collieries suffer most are cholera, small-pox, dysentery and pneumonia. Owing to the frequent and uncontrollable outbreaks of cholera and small-pox in the collieries, the Asansol Mines Board of Health was brought into existence to prevent the outbreak and spread of dangerous epidemic diseases. Besides the risks of accidents, they suffer from hook-worm infection, owing to the unsatisfactory method of disposal of excretal matter. Although hook-worm infection is widely spread in this settlement, hook-worm disease is absent. The percentage infection amongst the underground workers is 15 to 20 p.c. higher than amongst workers on the surface. Women are less infected than men.

Ventilation in Mines.—Owing to the evolution of gases such as *fire-damp* (consisting of methane, CH_4 and occasionally ethane C_2H_6), *after-damp* (carbon monoxide), and *white-damp* (CO or H_2S) in coal mines, arrangements have to be made for artificial ventilation. Fire-damp explodes when present in the proportion of 5 to 13 p.c. and is recognised by the appearance of a pale "cap" of flame over the ordinary flame of the lamp. After-damp or carbon monoxide is formed after explosion, and also from spontaneous oxidation or combustion of the coal in the "gob" or waste and from fires. The gas replaces oxygen in the red blood-cells, and if the air contains over 0.2 p.c. it will cause death. *Black-damp* is air from which whole or part of the oxygen has been removed by combustion or oxidation of iron pyrites present in the coal. This gas is normally found in mines, but is formed in the largest quantities in old and ill-ventilated workings. Its presence causes the light to become dim, and if present in large quantities the light is extinguished. Owing to the presence of these gases in the air of coal mines an abudant supply of fresh air is necessary to minimise the dangers arising from them. Ventilation is done by the use of large centrifugal fans at the head of the up-cast shaft which abstract the air.

OFFENSIVE TRADES

Certain trades require to be supervised by sanitary officials partly on account of their being a source of nuisance, because the smell or effluvia which they give off might act injuriously on the health of the people, and partly on account of the materials or process employed having an influence prejudicial either to the health of the workmen or of the surrounding population.

1. **Keeping of Animals.**—In rural districts the keeping of animals is not likely to cause much nuisance; it is only when they are kept in crowded, ill-ventilated, and badly drained localities in towns, that the emanations become a source of nuisance. Pigs, horses, cows, and other animals often create a nuisance chiefly from the storing of grains and other food-stuffs in a wet state and the accumulation of dung and soakage of urine, etc., into the ground owing to imperfect or defective flooring. Cowsheds and stables should therefore be properly constructed (*q.v.*). The discharges should be received in covered vessels and the sheds should be washed and cleaned daily.

Pigsties also create a serious nuisance from the smell of the sour and decomposed rice on which pigs are usually fed. The food should be stored in impervious vessels with proper covers. The sties are as a rule kept in a very filthy condition.

The keeping of poultry is also a source of nuisance and should be discouraged in small houses and cellars.

2. **Slaughtering of Animals.**—Slaughter-houses may be either *private* or *public*. Private slaughter-houses, as conducted in this country should be discouraged, as they not only facilitate the slaughtering of diseased animals, but are generally a source of very serious nuisance, especially when not managed under proper supervision. Nuisances arise from the dirty way in which the animals are usually kept. The storage of decomposed carcases and garbage also adds to filthiness.

Slaughter-houses.—Filthy slaughter-houses are always a menace to public health owing to the large collection of offal undergoing putrefaction, and the continual flow of blood, urine and faecal matter. It is essential for proper sanitary control that all slaughtering should be done in a public slaughter-house or "abattoir." These should be built with brick and concrete and well protected against rats. In the construction of a slaughter-house the following points should be noted:—

1. It should not be within a hundred feet of any dwelling-house, and should be open to the outside air at least on two sides for proper ventilation.
2. It should always be above the ground level.
3. There should be no room or loft over the slaughter-house.
4. There should be an abundant supply of water, and the cistern for storing water should be placed a few feet above the floor.
5. The floor should be made of some impermeable material with a proper slope and a channel leading to a gully, provided with a trap to prevent emanation of offensive gases from entering the slaughter-house.
6. The walls in the interior should be covered with hard, smooth and impervious material preferably by glazed bricks

or tiles to a sufficient height from the floor. The corners should be rounded off, and the slightest cracks on the floor repaired without delay.

7. There should be no direct connection between a water-closet or privy within the slaughter-house.

8. Doors and windows should be self-closing and have wire-netting to prevent flies and other insects from entering.

9. Dogs and rats should not be allowed around the slaughter-house on account of the danger of *trichinosis* and *echinococcus* disease.

10. The employees must be cleanly and wear clean outer clothes.

11. Persons suffering from any communicable disease, like tuberculosis, should not be allowed to handle any meat or meat products.

12. Butchers who handle diseased carcases should wash their hands in some disinfectant solution, and all instruments used must be sterilised.

13. All refuse, blood, manure and garbage are to be placed in vessels of non-absorbent material with close-fitting covers immediately after slaughtering to prevent vultures and other birds from scattering them about. Skins, fat, etc., should be removed from the slaughter-house as soon as possible.

3. **Blood-boiling or Blood-drying.**—Blood collected from slaughter-houses is utilised for *(a)* making blood albumin, *(b)* manufacturing turkey red pigment, *(c)* preparing blood manure, and *(d)* refining sugar. Blood is boiled usually with an admixture of common sulphuric acid and then dried. During this process the smell given off is very sickening.

Sanitary Precautions.—The floor, vessels, etc., should be kept scrupulously clean, and blood, when not in use, should be properly stored to prevent the escape of offensive gases. There should be proper arrangements for drainage and for the condensation of escaping gases, which are usually offensive.

4. **Bone-boiling.**—This is rather common in this country owing to the increased demand for phosphatic manures in tea gardens. The accumulation of bones in a raw state soon becomes offensive especially during the summer and rains. The storage of raw bones should not be permitted in or near dwellings, as the odour given off is very disagreeable. Bone-boiling, when the bones are perfectly fresh, is no more offensive than cooking on a large scale. But if the bones are tainted and decomposed they give rise to a very serious nuisance. Putrid bones, hoofs and horns, if left in the open, become extremely offensive, breed flies and cause sickness.

Sanitary Precautions.—The premises should be cleansed daily and all refuse collected and removed. All receptacles should be kept clean, and materials not for immediate use

should be stored in such a way as will prevent effluvia. Keep the walls and floors in good order and lime wash twice a year. The storing of bones should be in suitable sheds and the use of steam-jacketed cylinders for condensing vapours enforced.

5. **Gut-scraping.**—This is generally done for the purpose of making sausage skin, catgut, etc. The small intestines of swine and sheep are first washed and cleaned and softened by soaking in salt solution for a few days, and then scraped on a bench with a piece of wooden scraper until only a little of the muscular coat and the peritoneal covering are left. These are finally washed and dried.

Nuisance is prevented by (*a*) making the floors and walls of non-absorbent materials; (*b*) proper drainage arrangements; (*c*) providing marble-topped tables; (*d*) prompt removal of waste materials; (*e*) careful washing and cleaning of the premises; and (*f*) preventing improper and prolonged storage.

6. **Fat and Tallow Melting (Soap-boiling).**—Fat is usually obtained from butchers or marine store dealers in a more or less decomposed condition. It is utilised in the manufacture of candles, soaps, leather-dressings, and preparations for lubricating machinery. In the manufacture of soap, fat is boiled with an alkali generally called the 'lye.' Tallow was formerly melted by boiling in pans heated by direct fire, and unless the contents were constantly stirred, the fat was likely to get charred giving off offensive odour. But now the tallow is boiled in pans which are steam jacketed and the vapours are caused to pass under a furnace, and thus the nuisance has been minimised, though an unpleasant smell is given off.

Nuisance may arise from (*a*) improper conveyance or storage of material; (*b*) storage of residue; (*c*) general filthiness and unsuitability of the premises; and (*d*) vapours escaping during the process of melting or boiling the fat.

7. **Fellmongering.**—A fellmonger prepares either fresh or old skins for the leather dresser. The fresh skins are first beaten to get rid of the dirt, and then soaked in water in large tanks (pokes). The hair is removed by painting the inner side of the skins with a solution of slaked lime and sodium sulphide, which act as depilatories; and within 12 to 24 hours the hair is easily removed without causing much nuisance. Formerly the process involved some putrefaction which gave rise to considerable nuisance. This process has now been abandoned. Any nuisance that may arise is due to want of general cleanliness.

The process of tanning is very offensive and consists in soaking the hides in progressively stronger solutions of nut galls, reinforced by solutions containing tannin. In some process 'puer' or dog's dung, or pigeon's dung is used to

under the skin supple. By the process of "tanning" the putrescible hides are converted into non-putrescible and more or less flexible material commonly known as "leather." Tanneries, when conducted on European models are not, as a rule, productive of much nuisance. Still on account of the offensive odours they give off they should be located on the outskirts of towns. Small tanneries are usually productive of great nuisance, which is heightened by the wash water (largely impregnated with decomposing animal matter) being allowed to run into open surface drains or into waste lands.

Nuisances arise from (*a*) filthiness or unsuitability of building; (*b*) improper conveyance or storage of skins; and (*c*) unsatisfactory method of disposal of the dirt, flesh, and waste water. All offensive materials should therefore be conveyed in non-absorbent covered receptacles and kept in special closed rooms ventilated by means of air-shafts. General precautions are the same as those indicated for other trades.

8. **Paper-making.**—Paper is prepared from such substances as cotton or linen rags, waste paper, straw, bamboo, esparto grass, etc. The rags are dusted and then cut into small pieces, washed and bleached. Esparto grass is reduced to a pulp by first boiling with caustic alkali. Nuisance is caused chiefly by the alkali waste, which should not be allowed to run into any stream or ditch near habitations. The collection and storage of the materials is also a source of danger to the public health. The vapours given off during the process of boiling esparto grass with caustic alkali are also offensive and should be conducted by a flue to a tall chimney. Modern method of making paper pulp by treating bamboo pulp with SO_2 may give rise to a serious nuisance.

9. **Dusty Trades.**—Certain industries give rise to a considerable amount of dust which has been associated with the production of various forms of ill-health. Constant inhalation causes irritation of the nasal passages and produces a condition of the lungs known as *pneumonoconiosis* which may be of different forms according to the nature of dust inhaled, *viz. anthracosis* from coal dust, *silicosis* from stone dust, *asbestosis* from asbestos, *siderosis* from iron dust, and *byssinosis* from cotton dust. Apart from its effects on the respiratory tract, dust of different industries also causes certain diseases of the throat, eyes and skin. Various micro-organisms are conveyed through dust, *e. g.* tubercle and anthrax. Lehman has shown that of the dust inhaled through the nose and mouth only about 25 p.c. reach the lung, the rest being swallowed, and if the dust contains any poisonous substance like lead, absorption will take place through the alimentary canal.

Industrial dust may be of mineral, vegetable or animal origin. The various dusty trades and occupations are jute, flax and textile industries; lead, copper, iron, cement and

lime works; handling of leather, silk, wool, cotton, paper, etc.; drilling and cutting of stones, bones and horn; flour mills, etc.

Workers in jute, cotton and flour industries suffer from breathlessness, and develop symptoms of asthma with loss of chest expansion and immobility of the diaphragm. The most dusty processes are carding and spinning. Wool-sorters occasionally suffer from anthrax. Mill-stone cutters, stone masons, pearl cutters, sand-paper makers, knife grinders, millers, hair dressers, fur dyers are prone to suffer from diseases of the lungs. Constant inhalation of very fine particles of silica dust is the most dangerous of all owing to the great liability of the injured lungs getting infected with tubercle bacillus. Cigar makers inhale the dust of tobacco leaves and may suffer from tobacco poisoning. Coal miners suffer from *anthracosis*, and workers in gold mines who inhale rock dust suffer from *silicosis*. There is definite evidence that fibrosis of the lung caused by the inhalation of silica dust is particularly favourable to the tubercle bacillus, and that the course of tuberculosis in these cases is rapid. It is therefore obvious that the inhalation of this dust must influence the incidence of tuberculosis amongst the general population by increasing fresh sources of infection. The control of silicosis includes medical measures for its detection, and engineering measures directed against dust hazard. In South Africa both dry and wet methods of prevention are in use. Thus blasting only takes place at the end of the day's shift, and all unnecessary exposure to dust is carefully controlled; only machine drills which have an axial water feed may be used; and water is used for laying dust and removing it from the air. Although the visible dust has been controlled, the hazard has not been entirely removed, since it depends so much on the minute particles which float in the air, almost like gas. (*British Medical Journal, April*, 16, 1932). Commercial asbestos

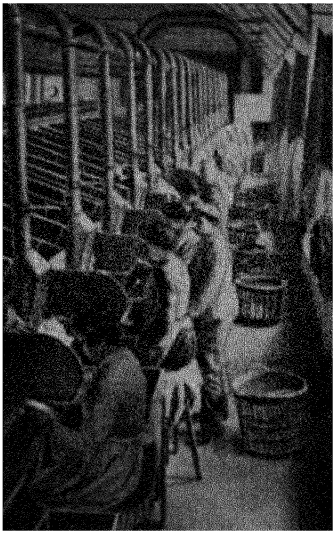

FIG. 25.—DUST REMOVAL PLANT. Rag-cutting room in a paper mill. Each operator works opposite an exhaust hood through which dust is drawn away. (Courtesy of Sturtevant Engineering Co., London).

consists of silicates, the silica being combined chiefly with magnesium or iron, and in smaller amounts with sodium, calcium and aluminium. Constant inhalation of asbestos dust gives arise to *asbestosis* which leads to fibrosis of the lungs and the presence of asbestosis body in the sputum. The effect of the tubercle bacillus on a lung affected with asbestosis is not at present so well established. Pulmonary asbestosis is insidious in its onset, irregular in its course and variable in its mode of termination. The fatal issue is determined by the onset of some acute infection with which the remaining undamaged lung tissue is unable to cope. Brass founders inhale oxide of zinc and suffer from diarrhœa, cramps, etc. Match makers inhale the fumes of phosphorus and suffer from necrosis of the jaw. Those engaged in the preparation of glass mirrors often suffer from mercurial poisoning, while workers in lead and plumbers are exposed to lead poisoning.

Preventive Measures :—1. *Prevention of Dust Formation.*—The amount of dust may be lessened by the use of oil, water or steam. The use of water (automatic water spraying) has given good results in rock drilling or stone crushing. The "wet" method is specially useful in pottery and lead industries.

2. *Prevention of Escape of Dust.*—When it is not possible to prevent the formation of dust, the nuisance created by the escape of dust can be prevented by the use of special cabinet or boxes for the machinery.

3. *Removal of Dust.*—When any of the above methods cannot be applied, or is not practicable, measures should be taken to remove dust by special means, *e.g.* by suction fans, or by special ventilating arrangements. (*See* Fig. 25). The Labour Commission recommended that owners of existing tea factories should be required to install efficient dust extracting machinery, and new factories should not be allowed to build without it.

10. **Oil Mills.**—In Calcutta and other places there exist a large number of mills for expressing oils. Mustard, cocoanut, ground nut, til and linseed are largely used. In the primitive form wooden presses (*ghanis*) are used and are worked by bullocks. The room is usually dark and ill-ventilated, and the floor without any proper pavement so that it becomes foul with the solid and liquid excreta of the animals. It is desirable that these mills should be worked by mechanical power to minimise the nuisance. If it is not possible, special arrangements should be made for stabling the animals outside the main building. The floor should be properly paved and made impervious to prevent soakage, and provision made for efficient drainage. The room should have ample openings for ventilation. The smell evolved from these mills causes great discomfort to the people of the locality, therefore, they should be located away from crowded quarters.

The oil and the crushed seeds should be kept in well covered receptacles.

11. **Rice Mills.**—In the preparation of rice the paddy is first put into metal jars or cylinders where it is steamed for 10 to 15 minutes, it is then removed and soaked in large cemented tanks or vats filled with water for 24 to 36 hours. After another process of steaming it is dried in the sun and then husked by machinery. After the paddy has been soaked the water becomes dark reddish-brown which undergoing putrefaction gives off offensive smell and creates a nuisance. It should not be allowed to run into any tank, open drain or stream without being first treated with chlorinated lime. Nuisance also arises during the process of winnowing from the accumulation of large quantities of husk and dust; these should be removed as quickly as possible. Further nuisance is caused when the machines are run by oil or steam engines. The Labour Commission made the following recommendations: In new rice mills steps should be taken to compel the installation of necessary protective machinery against the dissemination of dust, and freer use should be made of the power of inspection to demand its installation in existing mills. Where women are employed in any process creating an impure atmosphere the owner should be required to set up some temporary shelter in the compound for their infants.

12. **Smoke Nuisance,** *see* page 68.

THE INDIAN FACTORIES ACT, 1911 (ACT XII OF 1911)

As Modified up to the 1st June 1926

Sec. 3. (3) "factory" means

(*a*) any premises wherein, or within the precincts of which, on any one day in the year not less than twenty persons are simultaneously employed and steam, water or other mechanical power or electrical power is used in aid of any manufacturing process;

or (*b*) any premises wherein, or within the precincts of which, on any one day in the year not less than ten persons are simultaneously employed and any manufacturing process is carried on, whether any such power is used in aid thereof or not which have been declared by the Local Government by notification in the local official Gazette, to be a factory.

Inspectors and Certifying Surgeons

4. (1) The Local Government may, by notification in the local official Gazette, appoint such persons as it thinks fit to be inspectors of factories within such local limits as it may assign to them respectively.

(2) No person shall be appointed to be an inspector under subsection (1), or having been so appointed, shall continue to hold the office of inspector, who is or becomes directly or indirectly interested in a factory or in any process or business carried on therein or in any patent or machinery connected therewith.

(3) The District Magistrate shall be an inspector under this Act.

(4) The Local Government may also, by notification as aforesaid

and subject to the control of the Governor General in Council, appoint such public officers as it thinks fit to be additional inspectors.

(5) Subject to any rules in this behalf, an inspector may, within the local limits for which he is appointed,—

(*a*) enter, with such assistants (if any) as he thinks fit, any place which is, or which he has reason to believe to be used as a factory;

(*b*) make such examination of the premises and machinery and of any prescribed registers, and take on the spot or otherwise such evidence of any persons as he may deem necessary for carrying out the purposes of this Act; and

(*c*) exercise such other powers as may be necessary for carrying out the purposes of this Act.

(6) The Local Government may appoint such qualified medical practitioners as it thinks fit to be certifying surgeons for the purposes of this Act.

7. (1) A certifying surgeon shall, at the request of any person desirous of being employed in a factory situated within the local limits for which he is appointed, or of the parent or guardian of such person, or of the manager of the factory in which such person desires to be employed, examine such person and if he is fit for employment in a factory grant him a certificate in the prescribed form, stating his age, as nearly as can be ascertained from such examination, and that he is fit for such employment.

(2) A certifying surgeon may revoke any certificate granted to a child under sub-section (1) if, in his opinion, the child is no longer fit for employment in a factory.

HEALTH AND SAFETY

9. The following provisions shall apply to every factory:

(*a*) it shall be kept clean, and free from effluvia arising from any drain, privy or other nuisance;

(*b*) it shall not be so overcrowded while work is carried on therein as to be dangerous or injurious to the health of the persons employed therein;

(*c*) it shall be ventilated in such a manner as to render harmless, as far as practicable, any gases, vapours, dust or other impurities generated in the course of the work carried on therein that may be injurious to health;

(*d*) the atmosphere shall not be rendered so humid by artificial means as to be injurious to the health of the persons employed therein.

11. (1) Every factory shall be sufficiently lighted.

(2) In the case of any factory which is not in the opinion of the inspector so lighted, the inspector may serve on the manager of the factory an order in writing, specifying the measures which he considers necessary for the attainment of a sufficient standard of lighting and requiring him to carry them out before a specified date.

12. (1) In any factory in which humidity of the atmosphere is produced by artificial means, the water used for the purpose of producing humidity shall be taken either from a public supply of drinking water or from some other source of water ordinarily used for drinking, or shall be effectively purified before being used for the purpose of producing humidity.

13. Every factory shall be provided with sufficient and suitable latrine accommodation, and if the Local Government so requires, with separate urinal accommodation for the persons employed in the factory.

14. In every factory there shall be maintained a sufficient and suitable supply of water fit for drinking.

15. In every factory, the construction of which is commenced after the commencement of this act, the doors of each room in which

more than thirty persons are employed, shall, except in the case of sliding doors, be constructed so as to open outwards.

16. (1) Every factory shall be provided with such means of escape in case of fire for the persons employed therein as can reasonably be required in the circumstances of each case.

17. No person shall smoke, or use naked light or cause or permit any such light to be used, in the immediate vicinity of any inflammable material in any factory.

19. No woman or child shall be allowed to clean any part of the mill-gearing or machinery of a factory while the same is in motion by the action of steam, water or other mechanical power or electrical power, as the case may be, or to work between the fixed and traversing parts of any self-acting machine while such machine is in motion by the action of any power above described.

19A. Where, in the opinion of the inspector, the presence in any factory or any part thereof of children, who, by reason of their age cannot, under the provisions of this Act, be lawfully employed therein, involves danger to, or injury to the health of, such children, he may serve on the manager of such factory an order in writing, prohibiting the admission of such children to the factory or part thereof.

19B. No person under the age of eighteen years and no woman shall be employed in any factory in any of the operations specified in Part I of the Schedule, or, save in accordance with the regulations contained in Part II of the Schedule, in any operation involving the use of lead compounds (*see* page 110).

20. No woman or child shall be employed in the part of a factory for pressing cotton in which a cotton-opener is at work.

Hours of Employment and Holidays

21. (1) In every factory there shall be fixed

(*a*) for each person employed on each working day—

(*i*) at intervals not exceeding six hours, periods of rest of not less than one hour, or

(*ii*) at the request of the employees concerned, periods of rest, at intervals not exceeding five hours, of not less than half an hour each, the total duration of periods of rest on that day not being less than an hour for each period of six hours' work ;

(*b*) for each child working more than five and a half hours in any day a period of rest of not less than half an hour.

22. (1) No person shall be employed in any factory on a Sunday, unless (*a*) he has had, or will have, a holiday for a whole day on one of the three days immediately or suceeding the Sunday.

23. With respect to the employment of children in factories the following provisions shall apply :—

(*a*) no child shall be employed in any factory unless he is in possession of a certificate granted under section 7 or section 8 showing that he is not less than twelve years of age and is fit for employment in a factory and while at work carries either the certificate itself or a token giving reference to such certificate ;

(*b*) no child shall be employed in any factory before half-past five o'clock in the morning or after seven o'clock in the evening ;

(*c*) no child shall be employed in any factory for more than six hours in any one day.

24. With respect to the employment of women in factories the following provisions shall apply :—

(*a*) no woman shall be employed in any factory before half-past five o'clock in the morning or after seven o'clock in the evening ;

(*b*) no woman shall be employed in any factory for more than eleven hours in any one day.

27. No person shall be employed in a factory for more than sixty hours in any one week and for more than eleven hours in any one day.

THE SCHEDULE

(*See Section 19B.*)

Part I

1. Work at a furnace where the reduction or treatment of zinc or lead ores is carried on:
2. The manipulation, treatment, or reduction of ashes containing lead, the desilverising of lead or the melting of scrap, lead or zinc:
3. The manufacture of solder or alloys containing more than ten per cent. of lead:
4. The manufacture of any oxide, carbonate, sulphate, chromate, acetate, nitrate, or silicate of lead:
5. Mixing or pasting in connection with the manufacture or repair of electric accumulators:
6. The cleaning of work-rooms where any of the processes aforesaid are carried on.

Part II

1. Where dust or fume from a lead compound is produced in the process, provision must be made for drawing the fume or dust away from the persons employed by means of an efficient exhaust draught so contrived as to operate on the dust or fume as nearly as may be at its point of origin:
2. The persons employed must undergo the prescribed medical examination at the prescribed intervals, and the prescribed record must be kept with respect to their health:
3. No food, drink, or tobacco, shall be brought into, or consumed in, any room in which the process is carried on, and no person shall be allowed to remain in any such room during meal times:
4. Adequate protective clothing in a clean condition shall be provided by the employer and worn by the persons employed:
5. Such suitable cloak-room, mess-room and washing accommoda-tion as may be prescribed shall be provided for the use of the persons employed:
6. The rooms in which the persons are employed, and all tools and apparatus used by them, shall be kept in a clean condition.

Municipal Regulations of Factories, Trades, etc.

Sec. 385. (1) No person shall, without the previous written permission of the Corporation, newly establish in any premises any factory, workshop, or workplace in which it is intended to employ steam, water or other mechanical power.

The Corporation may refuse to give such permission, if they are of opinion that the establishment of such factory, workshop or work-place in the proposed position would be objectionable by reason of the density of the population in the neighbourhood thereof, or would be a nuisance to the inhabitants of the neighbourhood.

Trades not to be Carried on Without a License

Sec. 386.—No person shall use or permit to be used any premises for any of the purposes herein below referred to or mentioned, without or otherwise than in conformity with the terms of a license granted by the Corporation in this behalf, for the following purposes; (*a*) Casting metals, manufacturing bricks, pottery or tiles; (*b*) as a knacker's yard, hide godown or hide screw-house; (*c*) manufactory

or place of business from which offensive or unwholesome smells fumes or dust arise ; (*d*) as a depot for hay, straw, wood, coal, waste-paper or rags ; (*e*) packing, pressing, cleansing, preparing, or manufacturing clothes or threads in indigo or other colours, paper, pottery, silk ; (*f*) storing, packing, pressing, cleansing, or manufacturing any of the following :- blood, bones, candles, catgut, chemical preparations, china grass, cocoanut fibre, cotton or cotton refuse or seed, dammer, dynamite, fat, fins, fish, fireworks, flax, flour, gas, gun-cotton, gunpowder, horns, hoofs, hides, hemp, hair, iron, jute, leather, lime, manure, matches, meat, nitro-glycerin, offal, oil, oil-cloth, pitch, rags, rosin, salt-petre, skins, soap, spirits, sulphur, soorkie, tallow, tar, turpentine, wool.

Sec. 339.—(1) No person engaged in any trade or manufacture specified above shall (*a*) wilfully cause or suffer to flow or be brought into any tank, reservoir, cistern, well, duct or other place for water belonging to the Corporation or into any drain or pipe communicating therewith, any washing or other substance produced in the course of such trade or manufacture ; or (*b*) wilfully do any act connected with any such trade or manufacture whereby the water in any such tank, reservoir, cistern, well, duct or other place for water is fouled or corrupted.

CHAPTER IV

SOIL

SOIL is formed from the disintegration of the under-lying rock mingled with decayed vegetable and animal matter.

(*a*) *Upper or surface soil* is chiefly the outcome of decayed animal or vegetable matter forming mould or "humus." The depth of this layer varies from a few inches to several feet.

(*b*) *Subsoil* results from the disintegration of the underlying primitive rock through the agency of gases, water, etc. The depth of this layer also varies from a few feet to hundreds of feet.

Soils are divided into 2 groups (1) Residual, and (2) Drift. *Residual soils* are formed by the weathering of the subjacent rocks and are so-called because they remain *in situ*. Such soils may be formed from granite, gneiss, sandstone, limestone, in fact from any rock.

Laterite may be a residual or drift soil, but is usually the former. It exists over large parts of Central India, Chota Nagpur, Rajmahal and the Central Provinces, and parts of Assam and Western Bengal. A peculiarity of laterite soil is that kala-azar does not seem to flourish on it, though the reason for this may not be actually due to the soil.

Black Cotton Soil or 'Regur' is a residual soil found in many parts of the cotton districts of the Deccan. It is a finely grained black soil composed of clay, carbonate of lime and magnesia, iron and a large amount of organic matter. It is formed from the weathering of the Deccan Trap in certain areas being mixed with a large amount of 'humus' or vegetable organic matter from old jungle growth.

'*Reh*' is an efflorescence found in the plains of the Punjab and United Provinces. It consists mainly of carbonate, sulphate and chloride of sodium with some calcium and magnesia salts. It is due to these soluble materials having been brought down by the Himalayan rivers and being deposited in the soil by evaporation of the solvent water. It is bad for agriculture.

The *alluvial soils* or *Drift soils* are formed when the materials carried away by water are deposited elsewhere. They are found far inland in the valleys along which river flows, or in the deltas at the mouth of large rivers.

A knowledge of elementary geology, if not essential to the students of hygiene, is at least interesting and gives a point to many facts which might otherwise be obscure. Modern geology considers the earth's core to consist of a solid mass of iron and metal called for convenience the N, I, F, E. External to this is a zone of basaltic magma in which

float the continental masses of Asia, Europe, America, Africa and Australia. This basaltic zone is solid at the surface and forms the beds of the intercontinental oceans which stretch between the continents. The whole earth was once a molten mass and as it cooled, those minerals with a high melting point crystallised out slowly and formed the elementary continents. The chief of such minerals is *granite* which is composed of perfect crystals of *felspar*, *mica* and *quartz*. Felspar is of a pink colour and is present in granite as large pink crystals. Mica is usually brown or yellow but may be of various colours and exists as shiny flat hexagonal crystals, which sometimes may form large sheets. Quartz consists of fine clear crystals and fills up the space between the felspar and the mica. Granite still exists in many places of the earth in its unaltered state. In India it is found in a few places in the Himalayas and in Central India. These continental masses floated in the remaining basaltic magma which had a lower melting point—which later became solidified at its surface on which water condensed and formed the oceans. Condensation and rain began and resulted in the first "weathering" which is the term given to the process of disintegration of rocks by the action of water and dissolved substances in it, frost, wind and heat. The first granite masses were probably of soft texture and were easily broken up into their three primary constituents, felspar, mica and quartz. These got washed down into the surrounding shallow oceans and formed beds consisting of layers of the three constituents. A feature of the geological history of any country is the alternate risings and fallings of its land; for lengths of time it is under water, at other periods it is above water and makes land. The reasons for these alternate risings and fallings need not be discussed—one main reason is alterations in density of the basaltic magma in which the land masses float. One main effect is to raise marine sediments above sea level. These risings and fallings produce great stresses and strains and thrusts in the raised sediments. These are folded and corrugated and become mountain ranges. The stresses may be so severe that part of the folded land get pushed over other parts producing "faults" and fissures. These fissures may be so deep as to communicate with the liquid basaltic magma underneath which may then pour out and cover the land surface in the vicinity. This happened in India several times and the "Deccan trap rock" which covers a considerable portion of Central India and Bombay Presidency consists of solidified basalt outpoured through fissures in the past.

The crystalline rocks formed from granite in this way are called "gneiss" and consist of layers of quartz and felspar and mica—they occur in large quantities in India.

There is a more complicated "weathering" of granite and

gneiss, however, which is going on continually now and which is of considerable importance in producing soils. It is carried mainly by water containing dissolved CO_2. Ordinary felspar is a compound of silicates of potassium and aluminium. When acted on by water and carbonic acid, felspar breaks up into potassium carbonate, silica and hydrated aluminium silicate. This latter is "clay". The felspar crystals dissolve and disintegrate leading to the breaking up of the granite and gneiss. The mica and quartz remain chemically intact but get separated into individual crystals. The weathering of granite and gneiss therefore results in the breaking up of the rocks—pieces of rocks get broken off and small particles of quartz and mica and clay. A hill stream therefore could carry down boulders, stones, gravel, sand and clay. Sand consists of particles of quartz and mica, and usually some other mineral is present—the commonest of them is "hornblende," a compound silicate of magnesium and iron; this gives the small black specks in sand; the small shiny particles are mica and the small white particles are quartz. The soluble materials, such as potassinm carbonate, are carried away in solution.

The sand thus formed may be deposited on sea beds and later may be raised and form sandstone hills and mountains.

Basalt is a mixture of silicates of iron and magnesium and other metals. It is projected from volcanoes as lava, but the great masses on the surface of earth have come through fissures. It is a dark coloured heavy rock with a little or no crystalline appearance, it having cooled rapidly from a molten state. The weathering of basalt in tropical countries produces red coloured rock called "Laterite" which is a mixture of hydrated oxides of iron and aluminium. It is the principal rock and soil over large parts of Central India, Chota Nagpur and the western districts of Bengal. The further weathering of laterite gives bauxite, a pure oxide of aluminium from which alum cake is made. As an example of organically formed rock, limestone may be taken. This consists of $CaCO_3$. The shallow seas caused by the depression of land below sea level supported a great quantity of crustacean life whose shells fell to the bottom on the death of the animals—these shells were composed of $CaCO_3$ and formed great masses of deposits in the sea bed. Later when these beds were raised the deposits formed hills and mountains. Chalk is a smaller deposit of $CaCO_3$. This $CaCO_3$ might be dissolved as bicarbonate by water containing CO_2 carried away and deposited again as crystalline $CaCO_3$ by evaporation of the water and CO_2—an example of a chemically formed rock—marble is such a rock. In addition to the above, the following rocks should be known:—

Schists are simply gneissic rocks where the layers have

become differentiated as to become separable from each other. Mica schists are an example and are common in the Himalayas.

Dolomite is a mixture of $CaCO_3$ and $MgCO_3$.

Gypsum is $CaSO_4$.

Pyrites are sulphides, iron is the commonest.

Hornblende, a normal silicate of lime, iron and magnesia.

Talc is a silicate of magnesium.

Kaolin,—a very pure clay.

Green-sands,—sands containing a ferrous salt (glauconite).

Zeolites,—natural silicates of sodium and aluminium.

Physical Geology of India

The main features are simple. India consists of three parts.

(1) The Peninsula proper.

(2) The Indo-gangetic plain surrounding it on the north and separating it from

(3) The Himalayas or extra peninsular part.

The peninsula is of very ancient structure, that is, it has not been under sea level for many geological ages. Except for a strip of alluvial coast area, it is practically all composed of crystalline gneissic and schistic rocks. These represent the "roots" or bases of the old mountains which have been worn down to their present level. Over a large area comprising the Deccan, Central India, Central Provinces, Gujerat and Kathiwar, these old rocks are over-laid by the basalt of the Deccan trap, which flowed over these areas through earth fissures at various times. Scattered over the rest of the peninsula are some very old deposits of sandstones and clays. The peninsula is a solid mass of old rocks which has successfully withstood the lateral thrusts and stresses which have folded and raised the Himalayan area. This latter area is of comparatively recent growth and has been formed by the raising of an old sea bed with its deposits, the raising being accompanied by tremendous foldings and faultings. The main Himalayas are largely composed of gneissic rocks and schistic rocks while along the southern aspects are deposits of sandstone and other sedimentary rocks of tertiary or early recent age.

The great Indo-gangetic plain was a huge trough between the peninsula and the extra peninsular area, and has been gradually filled up by the sand, clay, and gravel brought down by the rivers from the weathering of the Himalayas and the peninsular rocks. It is therefore composed of sands, clay and gravel and is geologically uniform and monotonous.

Deltaic formation.—As there are local important differences in public health aspects between deltaic and non-deltaic areas, a short description of delta formation is given.

Actual delta formation is going on at the mouth of the Ganges and the Brahmaputra and the Indus, but elsewhere in the Gangetic plain the process has ceased. Where a mountain river debouches on the plains, its velocity at once decreases and the large stones are deposited in the centre of its course, dividing the stream into two branches. In these, with the decreasing velocity, fresh deposits of smaller particles take place, each deposit produces new channels. Stones, gravels, sand and clay become deposited, but owing to its finely divided nature, clay is the last to be deposited, its settlement only occurring in complete quiet. As the level of the country contiguous to the hills becomes raised, the material is carried onward to a lower area and so on; the mouth of the delta constantly advancing seawards. Floods in the river lead to inundation of the land over the banks of the river with deposition of sand and silt. The whole country therefore becomes formed of successive beds of gravels, sand and clay in various thickness and of irregular distribution according as the flood levels changed from time to time. The phenomena in an active delta are interesting and important. In an active delta, the numerous branches of the river communicate with each other and are all tidal; between the rivers are lower areas which become inundated twice daily by the flow tide. The tide flows up through the main river channel, through smaller channels and khals and overflows on to the wide low-lying areas or "spill areas" as they are called. At slack water some silt is deposited on these and at ebb flow the pent-up water of the spill areas rushes out through the channels or khals and frees them of deposited silt. Gradually however the spill area becomes naturally constricted by deposit of silt and the channels become tidal creeks which silt up from above downwards—and so the delta advances. A very similar set of phenomena happens in the yearly floods of water brought down by the rivers. The areas between rivers contain very low lying places communicating similarly by khals with the main stream. During a monsoon flood, the level of the water in the river rises and flood water flows through the openings into the khals, and thence to the low lying area or spill areas. The flood water carries rich silt which is deposited on the spill areas, the silt water itself is inimical to the growth of anopheles larvæ and hence these floods are beneficent agents to agricultural prosperity and freedom from malaria. At the end of the monsoon, the level of the river falls and the pent-up water of the spill areas rushes out through the khals or channels which are thus freed of deposited silt and kept open for next year's flood water. These spill areas and khals may die by becoming silted up naturally but any artificial contraction of the spill area or obstruction in the khal will hasten the process. The country behind an active delta, unless actively irrigated, tends naturally

to become drier, less productive agriculturally and more malarious. This is what has happened in some of the western and central areas of Bengal, and the problem of re-introducing flood irrigation in these areas is one of the most urgent importance. Sir William Willcox is of opinion that many of the dead rivers of these areas are old irrigation canals and that they could again be used as such if re-excavated and cleared, especially if the waters of the Ganges were held up by a barrage or dam placed across it in northern Bengal.

Composition of Soil.—Soil contains mineral and organic matters in varying amounts and about 33 to 50 p.c. of oxygen. The nature of the mineral constituents depends upon the character of the rocks from which they are derived. Besides oxygen, other elements present in the soil are carbon, silicon, hydrogen, chlorine, sulphur, calcium, magnesium, iron, etc. About two-thirds of the inorganic compounds are formed of aluminium silicate or clay. Iron is always present in the soil and imparts to it a red colour. Nitrogen exists as ammonia and its salts, nitrous and nitric acids, nitrites and nitrates. The organic matters are derived partly from animal and partly from vegetable sources. The vegetable organic matter exists in various stages of decomposition. The animal organic matter is derived from the decomposition of carcases and excreta of animals. The latter is present in the neighbourhood of human habitations, and if in excess in the soil it will pollute both the air and water of the locality.

Soil Features influencing Climate and Health

Certain features of the soil influence the sanitary conditions of the inhabitants. They are :—

Conformation of the ground and its relation to the neighbourhood as regards position and elevation. This depends on :—

1. The relative extent of hills and plains.
2. The height of the hills.
3. The direction of the main chains of the hills.
4. The angle of the main slopes of the hills.
5. The nature, size, and depth of the valleys.
6. The chief water sheds, and the direction and discharge of the water course, and
7. The amount of plain or flat land available.

Unhealthy spots among hills are closed valleys and places where there is stagnation of air, *e.g.* ravines. In the tropics ravines and *nullas* are usually unhealthy, as they very often contain decayed vegetation, and a current of air may disseminate mosquitoes from such marshy places. A *saddle back* is usually a healthy site, and so are positions near the top of a slope. Places at the foot of the hills, especially in

the tropics, are usually unhealthy, as they are damp and rich in organic matter on account of the accumulation of rain water and of the excessive growth of vegetable and animal life. Depressed or water-logged places are always damp.

Soil Air.—All the varieties of soil even the hardest rocks contain air in their interstices, but the actual percentage depends upon the looseness or otherwise with which its particles are packed together. Gravel, sand and sandstone being porous can hold considerable volumes of air. *Soil air* differs from the atmospheric air. It is usually moist, and contains oxygen less by what has been replaced by carbon dioxide resulting from decomposition of organic matter. The character of the ground air varies greatly depending mainly upon the character of the soil, the climate, the season and the rainfall. It contains a much larger percentage of CO_2 and less oxygen than ordinary air and a greater quantity of organic or other gases. The amount of CO_2 in the ground air of a particular area varies from 0.2 p.c. to 8 p.c. and depends on

(*a*) quantity of organic matter,
(*b*) permeability,
(*c*) depth, and
(*d*) temperature and moisture.

If the *ground air* of two soils similar as regards organic impurities, temperature and moisture, but of different permeability be examined, the less permeable one will contain more CO_2. The amount of CO_2 also increases with the depth. This is due not to increased chemical action, nor to the presence of more impurities, but to the air not getting an easy vent as in the more superficial layers.

A continual interchange between the soil air and the atmospheric air is going on which keeps the soil air moving. This interchange is influenced by

(*a*) difference in the temperature of the air and soil; when these differences are greatest, the widest range of movement of the ground air will occur;

(*b*) ground temperature;

(*c*) rainfall, a heavy rainfall is followed by a sudden rise in the level of the ground water and this will force out large quantities of ground air;

(*d*) barometric pressure; on the days of low pressure the ground air escapes from the soil; and

(*e*) movements of the ground water.

Soil air may occasionally be contaminated with poisonous gases derived from defective drains, cesspools, or "made soil," and may be aspirated into a house. This is of great practical importance from a sanitary point of view, and can be prevented by making the floors impervious by cementing or asphalting, or building the floor on arches. Instances are on record where coal-gas from leaky pipes has been

known to find its way into distant houses following the tract of water or drain pipes, thereby producing poisoning or explosion.

Soil Water.—Water exists in the soil in two forms, viz.—as (1) *moisture*, and (2) as *subsoil* or *ground water*. Most of the rain falling on the earth passes through its interstices to join the underground or sub-soil water, and this passage of water into the soil is essential for keeping the soil active. An absolutely dry soil, as in deserts, is lifeless and an excessively moist soil delays or hinders organic decomposition. In the deeper layers no bacterial action takes place, and vegetable matter remains unchanged almost indefinitely. The moisture of the soil is derived from :—

(*a*) rain,

(*b*) rise and fall of the ground water, and

(*c*) evaporation of subsoil water.

The absorbability of moisture varies with the soil ; open gravel absorbs least, about 10 per cent., while sandy or peaty soils absorb most, 60 to 80 per cent. Some soils, *e.g.*, hard limestone or dense clay, are practically impermeable to water, while others, such as chalk, sand and vegetable clay are permeable.

The depth of the subterranean water in any soil varies, sometimes it is 2 to 3 ft. from the surface, and in other cases as many hundreds. The depth to which the water descends varies indefinitely according to the nature of the soil. The level of the ground water is the depth of the water in shallow wells in the neighbourhood, but this level is liable to fluctuations depending upon the rainfall. In some places it lies just near and in others far below the surface. When it is near the surface, the ground above is always damp.

The ground water is constantly moving, flowing towards the nearest watercourse, river or sea. In India the changes in the level of the subsoil water are very great. At Jubbulpore it is from 2 ft. to 12 or 15 ft. from the surface ; at Calcutta from 5 to 15 ft. ; in Bengal it is generally from 2 or 3 ft. to 10 or 12 ft. from the surface. A soil with a low ground water level, *e.g.* 15 to 20 ft. is as a rule dry and healthy, whereas a soil with a high ground water level is damp and unhealthy. Sudden fluctuations of ground water are still more harmful to health.

Soil Temperature.—The soil temperature depends largely on the heat derived from the sun, and also to certain chemical and other changes taking place within itself, *i.e.*, on its geological formation. The temperature of the earth increases with the depth. The rate of increase in England has been estimated to be about 1°F. for every 50 ft. As soils conduct heat in varying degrees, the absorptive power varies as well. Green vegetation lessens the absorptive power of the soil, as evaporation occurs constantly from the

herbage. Damp soils are colder than dry ones, as the evaporation is continuously going on. The temperature of the soil is taken at a depth of 4 ft.

Soil Bacteria.—Garden soil and agricultural humus contain a large number of micro-organisms. They usually find in the soil all the conditions necessary for their growth and multiplication. Nutrition is derived from decomposition of organic matter, moisture, air and suitable temperature. These conditions are found more in the superficial than in the deeper layers of the soil.

One of the most important functions of the soil is the disposal and utilisation of organic matter. This is a complex process by which the proteins of the organic matter, animal and vegetable, are reduced to more simple and stable inorganic compounds. This disintegration is *purely a bacterial* action. Along with this process of *catabolism* there is also another phase, *anabolism* or building up process done by the living plants. These two processes—catabolism or breaking down and anabolism or synthesis—form the "nitrogen cycle" and occur in the superficial layers of the soil. This nitrogen cycle, which goes on in the soil through the agency of soil bacteria and plants, has an important bearing in the purification of water, prevention of soil pollution and disposal of sewage. Thus, when an animal or a plant dies, the protein constituents are acted upon by the putrefactive organisms, chiefly *B. subtilis* and *B. proteus*, and some bacilli of the colon group. These break up the nitrogenous matter into simpler products and a process of putrefaction and liquefaction takes place, when most of the bacteria pathogenic to man die. This putrefactive process goes on in the soil as long as the conditions for bacterial growth are favourable, *viz.* a suitable temperature, moisture and air. The breaking down of vegetable matter is however a slower process, since it contains less water and a smaller percentage of putrescible protein. The protein molecules are broken down by a process of hydrolysis into simpler amino compounds, the final products, amongst other substances, being carbon dioxide and ammonia. Part of the former passes into the atmosphere and the rest is retained in the soil as carbonates. Since ammonia, as such, cannot be utilised by the plants some of it also passes into the air and the rest remains in the soil as chloride or carbonate. The ammonia is oxidised by the nitrifying organisms in the soil into nitrates which are stable and represent the final stage of mineralisation. The nitrates are held in solution in the ground water and are either taken up by the plants or are washed away with the ground water. The presence of nitrates therefore in the water is of some significance. (*See* Chemical Examination of Water, page 58).

Varieties of Soil

Newsholme classifies soils as under :—

1. **Granitic, Metamorphic,** and **Trap Rocks** owing to the good drainage and slope are always dry and form healthy sites for houses. "Weathered" granite, however, is an exception to the rule, as it becomes disintegrated and softened, absorbs water, and becomes permeated with the lower forms of organisms.

2. **Clay Slate** is equally healthy, the water-supply and vegetation being less.

3. **Chalk,** when free from clay, is always a healthy soil but with clay, *i.e.*, marly, it is damp and cold.

4. **Limestone**, and **Magnesian Limestone Rocks** have considerable slopes, so that water runs off quickly. The hard oolite is the best and magnesian the worst.

5. **Sandstones.**—Here both the soil and air are dry, and therefore, healthy. If the sand be mixed with clay or if clay lie under a shallow layer of sand rock, the site is sometimes damp and cold. The hard millstone grit formations are healthy.

6. **Gravels,** unless water-logged, are healthy at any depth. Gravelly elevations are the healthiest of all sites, and the water-supply from them is usually pure.

7. **Sands.**—When of considerable depth and free from organic matter, these may be considered healthy, but when they are shallow and lie on a clay basis, or when the subsoil water rises through them to a high level, they are unhealthy. In the Punjab, sand contains lime, magnesium, and the salts of alkaline earth.

8. **Clay, Dense Marls, and Alluvial Soils,** owing to the retention of water in them, are cold and damp. A clay soil will improve by thorough drainage. Alluvial characters are to be seen in the deltas of big rivers.

9. **Cultivated Soils.**—Well-cultivated soils are frequently healthy. Irrigated lands favour the breeding of mosquitoes, therefore dwelling-houses should not be constructed in the vicinity of such places.

10. **Filled or "Made" Soil.**—When tanks, hollows, or other depressions of the ground are filled up with refuse, the resulting site is called *made soil*. The chief point to be considered in such cases is whether the local conditions are favourable for rapid disintegration of organic matter. The *complex organic substances are disposed of by the nitrifying micro-organisms and are converted into harmless inorganic* compounds which are finally removed by percolating rain water. Insanitary tanks or low-lying lands, where water can accumulate, should be filled up for improving the local sanitary conditions, but to carry this out effectively and without offence, certain precautions are necessary. The refuse undergoes fermentation and putrefaction with the formation of

gases, chiefly marsh gas, sulphuretted hydrogen, etc., which may travel a long distance underneath the ground and help breeding of flies. The serious nuisance and consequent ill-health can be avoided by attending to the following points:—

(*a*) All such sites should be dry, and in the case of tanks or land subject to flooding, the water must first be drained away and arrangements made to protect such areas by embankments.

(*b*) The refuse must be deposited in layers not exceeding 6 feet in depth which should be covered on all surfaces exposed to the air with at least 9 inches of earth or rubbish from dismantled houses. No refuse should be left uncovered for more than seventy-two hours. Use screens to prevent debris being blown away by the wind.

(*c*) Whenever practicable the filling should be completed before the onset of the rains, to prevent formation of offensive puddles and breeding of flies.

(*d*) For large tanks the water should be first drawn out and then partitioned either by means of bamboo matting or earthen dams, and each part taken in turn. The process should begin at one end and then gradually advance onwards.

(*e*) The land should not be used for some years (ten to twenty or even more according to the nature of the materials dumped) for building purposes, and should only be utilised for gardening or cultivation, care being taken to drain it properly.

(*f*) No dead animals, slaughter-house garbage or faecal matter should be thrown into the hollows.

(*g*) The hollows should be filled up to about 2 ft. above the surrounding area to allow for settlement.

(*h*) Each layer of refuse with the layer of earth should be allowed to settle before the next layer is deposited.

Dampness of Soil.—Damp soil is, as a rule, unhealthy, and, when permanently wet, it generally contains much organic matter. It is usually found that the health of those living in or near a damp place is inferior to those living near a dry one. To render the soil fit for habitation, proper drainage for readily carrying away surface or storm water without permitting it to percolate into the soil should be made. Wherever necessary, subsoil drains should also be constructed to lower permanently the level of the underground water.

According to Simpson the following are the causes of dampness:—

1. *Retentive Soils.*—Clay soil is difficult to drain and when the land is low-lying, swamps are easily formed which add to the unhealthiness of the locality. Alluvial soils when mixed with clay, sand, and a large proportion of organic matter, as met with in valleys or in low-lying lands, are also unhealthy.

2. *Impermeable Layer near Surface.*—The depth of the subsoil water should be at least 5 ft. from the surface. When the impermeable stratum is too close to the surface, it holds up the soil water very near to it.

3. *Borrow Pits.*—These are excavations made during construction of public roads or in railway works to form embankments, and for the supply of earth for building purposes. During rains they are converted into stagnant pools and marshes, and become ideal places for the breeding of mosquitoes. Since it is not possible to do away with such excavations, they should not be done at random. The best plan would be to have these excavations on either

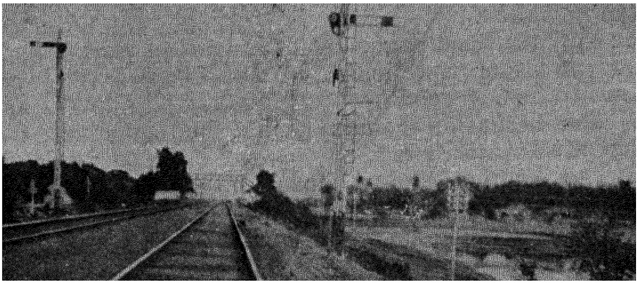

FIG. 26.—RAILWAY EMBANKMENT FORMING BORROW PITS.

side of the railway line in the form of long trenches which should open into some river or stream. It is quite common to find excavations and depressions in most villages. They from what are called *sand pits* and *clay pits*. These are made to supply earth for the purpose of building huts or for making bricks. They are very difficult to drain and add to the unhealthiness of the place. The best plan would be either to fill these up with the rubbish of dismantled houses, or, when this is not possible, to reserve a plot outside the town for the purpose of taking earth which in time may be converted into a decent tank, provided this is done systematically.

4. *Obstructed Drainage.* Obstruction to the flow of the underground water of natural drainage of the locality brought about by embankments, often gives rise to dampness and marshiness. That railways are responsible for the spread of malaria in certain districts may be best explained in the words of Professor Simpson : "Wherever railways do not follow the water shed of the district, ample provision should be made to secure diversion and a sufficient outlet for the drainage which is likely to be obstructed. In all new railways in the tropics this essential factor in the health of the localities through which the railways pass should be

insisted on. It is not an engineering difficulty that cannot be overcome."

5. *Silting up of Streams.*—This leads to the obstruction of the natural drainage and makes the place unhealthy and malarious. As an example may be mentioned the silting up of the water ways in different parts of Bengal.

6. *Neglect to Keep Clean Water-ways.*

7. *Introduction of Water-supply without Provision of Drains.*

Effect of Irrigation on Soil.—Irrigation makes a healthy locality unhealthy when not attended with efficient drainage. When a large volume of water is allowed to run into a district, the natural outlets which may have been sufficient for its drainage prove insufficient, making the soil damp and water-logged.

For the proper management of irrigation works in India, without affecting the health of the district, the following rules are to be observed :—*

1. The irrigation canals should be constructed along the line of the water shed.

2. The smaller canals should be so constructed as not to be carried across the natural line of drainage.

3. Drainage cuts should be constructed along the natural line of outfall.

4. The supply of water should be limited to the amount required, and to the particular time needed to secure the success of the crops.

DISEASES ARISING FROM THE SOIL

The upper few inches of the soil contain innumerable bacteria which give to the soil the sticky moist feeling so common with rich living soils. Very few bacteria are, however, found below the depth of 4 to 6 ft. in an undisturbed soil. Houston found on an average 100,000 per gramme in an uncultivated sandy soil, and 115,000,000 per gramme in a sewage soil, of bacteria which ordinarily grow in the usual laboratory media. The bacteria are either *saprophytic* or *pathogenic*, but the former are found in greater abundance. Pathogenic bacteria do not, as a rule, find a suitable medium in the soil for growth and development. Thus, Koch has shewn that anthrax and other pathogenic micro-organisms may grow on sterile soil but not in soil with ordinary soil-bacteria, *i.e.*, in living soil. These die in the struggle for existence. The soil, however, contains certain bacteria or their spores, *e.g.* those of malignant œdema, tetanus, etc.

Usually the soil is capable of disposing of organic matters. Without this property the earth surface would have long become clogged with these substances. But sometimes it is

* Simpson, *The Principles of Hygiene.*

unable to carry out this process, specially when overloaded. Under these conditions the soil remains polluted and may cause diseases through contamination of water or in other ways.

The soil was once held responsible for the spread of certain infectious diseases, notably typhoid and tuberculosis. Few pathogenic organisms, however, can actually live in the soil. But a soil polluted with human excreta may contain specific organisms and give rise to different types of intestinal troubles. Thus cholera, amœbic dysentery, typhoid, etc., may all be produced from infected or polluted soil indirectly through water, dust or flies. Certain vegetables eaten raw may communicate eggs of worms and bacteria in a mechanical way when grown on polluted soil. Finally, all water for drinking or otherwise must, some time or other, have passed through soil which materially affected its character. The infection contracted directly from soil polluted with human excreta is chiefly hook-worm, and the eradication of the disease depends primarily upon the prevention of soil pollution. Again tapeworm and other intestinal parasites pass part of their life-cycle on or in the soil.

Anthrax.—Under normal conditions, anthrax does not grow and multiply in the soil, although its spores have been found in fields where infected animals have been allowed to graze. Pasteur demonstrated the presence of the bacillus in the soil and believed that the spores were brought to the surface by earth-worms. The danger of infection from the soil is negligible and anthrax rarely occurs through soil infection. In fact there is no case on record where human anthrax has been contracted from contact with the soil.

Enteric Fever.—Enteric excreta when buried superficially in dry sandy soil may be carried about by air and infect food. It is hardly possible that the bacillus multiplies at all in the soil, as it rarely lives more than a month or at most three months. On the other hand, there are many possibilities of infection being conveyed through soil once it is polluted by typhoid excreta. Thus, the drinking water may be infected or the bacilli may be carried about mechanically by the agency of flies, dirt and dust.

Cholera.—In India, epidemics occur either during or after the rains which wash the bacilli from the surface of the soil into wells, tanks and other sources of water supply. Under normal conditions the bacilli die quickly when deposited upon or in the soil. It is possible that when the soil is infected with the excreta of cholera patients, the vibrios may be carried by dirt, flies and dust. Cholera is rarely contracted directly from the soil.

In India the evidence is in favour of the soil being a medium for the propagation of the disease inasmuch as the bacilli retain their vitality for a long time in the soil.

Diarrhœa (epidemic or summer).—This is associated with low-lying alluvial soil. The annual recurrence of diarrhœal affections, especially among infants, is often associated with the rise of temperature of the soil and consequent resuscitation to activity of certain pathogenic saprophytes to which these diseases are due, and to the changes effected by their means in milk and other food.

Animal Parasites.—It is well-known that hookworm infection is associated with soil infection through faulty disposal of excreta. Similarly the eggs of most of the intestinal parasites of man are deposited on the soil and re-infect man during one of the stages of their life-cycle.

Phthisis.—The effect of damp soil in the prevalence of phthisis is only indirect. Combined with cold wind, chill and moisture, it might induce respiratory catarrh and thus render persons more susceptible to the attack of tuberculosis, especially if the domestic and other conditions be insanitary.

Tetanus.—The natural habitat of the tetanus bacillus has been proved to be richly manured soil, specially the contents of dung heap where it is supposed to lead a saprophytic existence. The spores have been found not only on the superficial soil but at times a few feet under the soil. Although the bacillus has also been found in the dust of houses, on the skin and intestine of herbivorous animals, the soil is the chief medium through which the germs are distributed.

Malignant Œdema.—Wounds may become infected with soil containing spores of *vibrion septique* giving rise to *malignant œdema*, or of *B. welchii* (*perfringens*) causing *gas gangrene*.

CHAPTER V

HOUSES AND BUILDINGS

The selection of the site for building purposes is often done without any regard to its suitability from a sanitary point of view. The primary consideration in the selection of a site should be dryness, warmth, light and air. The following points require careful attention :—

1. Since dryness of the soil is dependent upon the facility with which rain water can pass off, the ground selected must be high with a sufficient slope to allow the rain water to be drained off rapidly.
2. Permeability of the soil should not be overlooked. The soil should be of a loose gravelly nature to allow free drainage. The worst soils are shallow beds of gravel or sand lying over clay, as also alluvial tracts, owing to their frequent water-logged condition. Made ground should, as a rule, be avoided.
3. The building should be open on the east and south to allow free passage of light and air, and a part of it at least should be exposed to the sun.
4. Vegetation around the house will keep it cool, but if it be too close it may make the house damp by obstructing light and air.
5. The site should be at a distance from marshes, paddy fields, cowsheds, stables, etc.
6. The surface soil or subsoil should not be polluted by sewage or other refuse, and the surface drainage of the soil must be good.
7. Vicinity of a bazaar or a *bustee* should be avoided. Places close to trenching grounds, open lands where refuse is thrown, or factories, etc., are unsuitable for building purposes.
8. A site with a constant level of subsoil water is better than a place where the subsoil level varies in different seasons of the year. The ground water should be about 6 ft. below the surface and not subject to sudden changes.
9. When selecting sites for building *cooly lines* attached to tea gardens, mills and factories, these should be on a healthy site, and away from damp and marshes.

Construction of Houses

The value of well-ventilated and well-lighted houses is being forcibly brought home to us daily. When it is remembered that sunlight not only kills germs but is a valuable means of producing vitamin D from the skin, it will be at once obvious

that its deficiency in ill-lighted and ill-ventilated houses will have a deleterious effect on the health of the people. Rickets and osteomalacia are diseases now common in this country, and are found in overcrowded cities and towns with narrow lanes and high sunless houses, and in densely populated bazaars amongst purdah observing women and their children. In fact Dr. Degmar Curjel Wilson (*Lancet*, *July* 4, 1931) as a result of investigation on the diet, housing and custom of 1500 cases of rickets and osteomalacia in Northern India, has pointed out that deficiency of vitamin D in the food supplemented by a lack of sunlight is the chief etiological factor in the production of these conditions.

The result of building houses without any regard to the sanitary conditions is well examplified in every old town or city in India. It is only within recent years that any attempt has been made to construct houses with a properly laid out town planning. Indeed it is a big financial problem to rebuild a city on modern sanitary lines; although attempts are being made by the Improvement Trusts, as in Calcutta and Bombay. The modern town planning is well illustrated in the New Delhi which stands in contrast to Old Delhi a congested area with insanitary houses abutting narrow lanes and by-lanes. Once a city has been allowed to grow it becomes very difficult to modernise it without the largest measures of demolition and reconstruction.

An important consideration in the building of houses in the tropics is to keep them cool. Therefore such material should be used as will reflect as much heat as possible. A convenient way is to have a verandah against the room to intercept the direct sun's rays.

Another pernicious system which also exists is to build what are known as *back-to-back* houses. It is obvious that cross ventilation is impossible in such houses and the rooms are naturally dark and ill-ventilated. Back-to-back houses are unfortunately the rule in blocks of dwellings build for the labourers in mills, factories, railways, etc., generally known as *cooly lines*. This should be forbidden in all new constructions.

A house must be dry, properly lighted and ventilated: a damp building harbours disease. Dampness may originate from the soil on which the house stands, from bad drainage and leaky roofs, or from planting trees too near to the house. Bricks by their capillary attraction draw up moisture from the soil and make a house damp. Ill-ventilated and closed houses without a sufficient number of doors and windows for admitting light and air are always damp. It is almost impossible in India to adequately ventilate a room by natural means, unless arrangements are made for cross ventilation through doors and windows. Situated in narrows lanes as most of the houses in congested parts of towns are, with a

narrow frontage, and wedged in between adjoining buildings, three out of four blocks are absolutely shut in, save for the tiny courtyard which in lofty buildings is almost well-like. The oriental style of constructing houses with an open central court has the advantage of admitting light and air into the interior of each room, provided the area of the courtyard is in proportion to the height of the structures around.

The system of dividing dwelling-houses amongst several co-heirs is a potent factor in the production of insanitary property. Each co-sharer erects as lofty a masonry wall as he possibly can, so as to shut off completely his share from the rest. The result too frequently is that a noble mansion with spacious courtyards is converted into a number of mean little houses having totally inadequate open spaces with most of the rooms imperfectly lighted and ventilated.

The foundation must always be solid and substantial. When the soil is soft and yielding, the walls should be broad and built on a solid basis of concrete. In making the foundation the ground should be dug up, and then a bed of good cement concrete made covering the whole site of the house and extending six inches beyond the "footings" of the walls on every side. The object of laying this bed of concrete is to prevent subsidence which occurs in buildings erected on a loose soil or with bad concrete. The depth of this concrete should depend upon the weight of the wall which has to be supported and in no case should be less than 18 inches. In addition to this bed of concrete a layer of impervious material known as the "damp-proof course" should be laid horizontally along the entire thickness of each wall, above the point where the wall leaves the earth, but below the level of the floor. This is necessary to impose a barrier to the upward progress of the moisture. By capillary attraction the bricks absorb moisture from the soil even as far as the upper rooms thus making the house damp and unhealthy. The materials used for the damp-proof course should be impermeable to moisture and sufficiently strong to stand the superincumbent weight and unequal pressure, and may consist of one of the following :—

1. Sheet lead,
2. two layers of roofing slate,
3. a layer of good asphalt 2 in. thick,
4. well-tarred bricks, and
5. patent stone one inch thick made with stone chips, cement and stone dust.

Walls.—The materials usually employed for the construction of the walls of dwelling houses are bricks, stones, or wood. A good brick should be well burnt, of regular shape, of uniform colour, and when struck should give a clear metallic sound. Ordinary bricks are porous and allow air and moisture to pass through them. The brick work of the wall should be at least 15 in. thick ; the thickness is usually

regulated by consideration of stability and height. The bricks should be properly bound together by being laid length ways and cross ways alternately. Wood, unless well seasoned, should not be employed. A thin-walled house is hot in summer and cold in winter. It is necessary that the outer walls above the ground level should be so constructed as not to admit damp even if exposed to rain and wind. Hollow external walls would resist any amount of damp, and consist of parallel walls separated by an air space of about 2 in. and tied together by binding ties of iron ; but the constant presence of rats, etc., within double walls makes it difficult to prevent a nuisance arising therefrom. A good plan therefore is to fill the space between two such walls with asphalt, thus forming a vertical damp-proof course.

The walls of houses are mostly plastered and white or colour-washed outside. The plaster consists of a mixture of *chunam* (lime) and river sand. It has been the custom to leave the outside walls with bricks exposed, but for this neat work with good bricks is required. Although this looks well and refreshing to the eye, it makes the buildings proportionately hotter.

The walls in the rooms are covered with sand plaster. Ordinarily this consists of two layers, the first is a mixture of lime and sand half to one inch thick and the second of slaked lime mixed with water to the consistency of cream. The treatment of this surface of the room however differs ; it may be :—

(*a*) *Limewashed* with quicklime and water.

(*b*) *Whitewashed* with a mixture of whiting or finely ground chalk and water. Some alum or gum may be added to protect it from being rubbed off.

Oil painting of walls is also done. This renders the surface impervious and enables it to be easily washed. The painting of wood and iron work with oil paints is valuable as a preservative. Papering is rather rare in India, being rapidly deteriorated by the climatic conditions that prevail.

The upper floors may be made of wood, or terraced and cemented. *Floors* should be made of some impervious materials which can be washed. Bricks, stones, tiles, broken bricks and mortar, cement, asphalt, etc., are all used for the purpose. The floor of the ground storey should invariably be air and water-tight. The concreted floors should be covered with a layer of good cement, patent stone, or, in better-class houses, with marble slabs.

The chimney flues are as a rule not required except in houses built in the hill stations. They should be circular, straight, and higher than the surrounding buildings, and not made of any inflammable material. They should be constructed during the erection of the house wall.

The roofs of Indian houses are either flat (terraced), or

sloping. *Flat roofs* should have just enough slope to allow rain-water to flow off. Roofs should always be high, as the heat radiated from a roof is in inverse ratio to the square of its distance. They afford a promenade and place for sleeping during hot weather.

Sloping roofs may be either of tiles, slates, thatch, corrugated iron, etc. Tiled roofs are coming more into fashion with the introduction of different varieties of tiles. Thatched roofs made of hay or straw, spread on a bamboo framework, and about 6 to 12 in. thick, are often used for the construction of bungalows, especially in those parts of India where the heat is great. These are very cool and dry, but their liability to take fire easily and the shelter they give to rats, insects and other animals are the great drawbacks. This may partly be obviated by occasional renewals. A double roof with a space between should make a very cool covering to a dwelling. Corrugated or galvanised iron used as a roof covering is very hot in summer and noisy during the rains, but is well suited for hill stations.

The height of the rooms should be at least 10 ft. and every room must have at least one window opening to the outer air direct. But very great height is not desirable unless proper arrangements are made for the exit of foul and warm air from the upper part of the room.

The *kitchen* should not be near a privy, nor so placed as to allow the smoke and smell of cooking getting into the rest of the house. It should not be on the side of a busy road and thus be exposed at all times to the dust and the impurities it contains. It must be provided with fly-proof automatic closing doors and windows. The openings for the exit of the smoke should be as near the ceiling as possible. It should have floors with impervious materials, *e.g.* cement concrete or brick-on-edge, and have proper arrangement for washing. The garbage should be collected in a special covered receptacle which should be emptied at regular hours at least twice a day.

Water-closets or *privies* should be confined to one part of the house. At least two sides, if not more, should be open to the outside air, and the floor and walls up to a certain height should either be plastered with cement or covered with glazed tiles. In villages, where more land is available, the privy should always be at a distance from the main building.

Disposal of Rain and Slop Water.—Every house should be provided with rain-pipes for getting rid of rain water. These may be either of wrought iron, tin or earthenware. Those made of wrought iron are the best. Houses with sloping roofs should have gutters all round the lower edge of the roof to catch the rain, with openings at intervals, whence the water should be carried down by ordinary rain-pipes.

In order to prevent surface water percolating into the ground and thus making the house damp, the surrounding area should be cemented and the water carried either direct into a yard gully or sewer, or into the main street drain through half-channelled open surface drains.

Disposal of Refuse.—Besides the building proper arrangement should be made for the removal of refuse. The refuse to be disposed of is of three varieties, *viz.* (1) *dry refuse*, such as ash, dust, waste paper, rags, vegetable and animal matter, etc.; (2) *liquid refuse*, or slop water from kitchen, bathroom and other washing places ; and (3) *human excreta*, consisting of urine and fæces. The garbage should be collected in metal receptacles, which should be emptied at regular hours, at least twice a day, into the public dustbin. In places where there are no sewers, the slop water should be disposed of by surface drains. But it would be better to allow the water to pass first through a sullage filter which is a trench filled with stone, clean gravel and loose earth and sand of each six inches. The disposal of human excreta either by the water-carriage system or by the hand-removal system is described under the respective chapters.

Proper Supply of Wholesome Water.—In places where there is a public water-supply very little difficulty will be experienced in providing sufficient water for drinking, cooking and washing purposes. But in the absence of such a supply, provision should be made for a deep well, reserved tank, or a tube well, care being taken to prevent contamination of water from different sources.

Open Space.—In cities and crowded places it is essential that there should be sufficient open space around each building. A back space of at least ten feet will do away with the possibility of the creation of "back-to-back" houses, while the side space will make the rooms bright and healthy and afford proper ventilation. In villages where the land is cheap there is always a compound round the building or bungalow, and a belt of gravel couple of feet wide around the building keeps off snakes.

The construction of well-ventilated houses on sanitary lines has been described above. These are possible in towns and cities, though the question of open space is an important consideration in these places where the value of land is so high that it is just possible to have only the building and its necessities. Open space around the house becomes more a luxury than a health question. In country districts where land is cheap much can be done to build healthy houses, but the provision for proper water-supply and the disposal of water and excretal matter is a problem to be dealt with, since the water-carriage system is non-existent in most villages and the disadvantage of hand removal system is well-known. The real problem which sanitary authorities have to face in

most of the tropical countries is housing of the poor both in towns and villages. Thatched houses with walls made of split bamboo and plastered with mud or plain mud walls are the rule. These cannot be kept clean and dry.

Another factor which makes houses insanitary even when otherwise built in healthy surroundings is the custom of keeping domestic animals within the building or even in some living rooms. It is a common practice to keep cows, goats, fowl and even horses in many houses. The insanitary condition which such a practice will create is obvious. The cowdung is collected in heaps and kept for days to undergo putrefaction while the breeding of flies goes on merrily. Food materials for these animals are stored in the house without proper protection, while waste materials and garbage are thrown about the house.

Overcrowding is another evil, and in England it is regarded a nuisance. Although the law does not define when a room or a house should be considered overcrowded, it is usual to adopt a standard of cubic space for each person, having due regard to age and whether or not the room is entirely used for sleeping purposes. The standard of cubic space has been given under ventilation (*see* page 76). It is still believed that overcrowding produces its harmful effects by causing vitiation of the air of the dwelling-room and emphasis is laid on adequate ventilation. Overcrowding and defective ventilation cause increase of temperature, excessive humidity and air stagnation of the room which lower the vitality of the inmates and make them more susceptible to disease. Those who work and live in badly ventilated rooms suffer from headache, languor, debility and anæmia. By shortening the path of the buccal spray, overcrowding helps communication of bacteria from one individual to another. Thus the bacteria of respiratory passages of persons suffering from catarrhal or infectious diseases may penetrate in large numbers the respiratory passages of other persons in close proximity. It is not uncommon to find occurrence of multiple cases of respiratory troubles, *e.g.* tuberculosis in a house which is overcrowded. Other diseases like measles, small-pox, influenza, etc., are associated with overcrowding. Another important feature of overcrowding is the greater incidence of contagious diseases, such as scabies, ringworm and ophthalmia. Typhus fever being a louse-borne disease, is associated with overcrowding due to poverty, and low standard of living. Apart from its association with disease it has a bad social effect specially when persons of opposite sexes occupy the same sleeping room. The lack of privacy which perforce occurs has the effect of dragging every one down to the same level of squalor which has a degrading influence on children and adolescents.

The Housing Problem

Nowadays, in cities like Calcutta and Bombay, various new problems relating to the construction of dwellings for proper accommodation of middle-class people are being seriously discussed ; the chief point to consider being how to obtain an abundant supply of air and light. To meet these ends, well-built, well-drained and healthy *residential quarters* or *lodging houses* are constructed.

A. Residential Quarters.—The following points should be attended to in the construction of a residential flat :—

1. The building, the drainage, and the water-supply should conform to the Municipal Act.
2. The staircase, flats and pantry should be well-lighted and aired.
3. The water-closet for each flat should be in a detached portion of the building, and the number should be in the proportion of one for six persons.
4. There should be abundance of water-supply and proper arrangements for efficient drainage.
5. Each block or flat should be complete with separate water-closets, baths, kitchen, etc.
6. There should be sufficient open space for each block or flat.
7. The kitchen should also be detached, to prevent smoke from entering into the residential quarters, and connected with the main building by a covered passage.
8. The servants' quarters should be either on the top floor with a separate staircase or away from the house but within the compound.

B. **Lodging House.**—By a "lodging house" is meant a house where persons are received for short periods (usually for the night), and although strangers to one another, are allowed to inhabit a common sleeping room. Such lodging houses exist in different pilgrim centers of India where people stay for a short time only. All lodging houses should be registered and periodically inspected.

The cubic space per head in a lodging house should not be less than 300 feet. The number of persons to be accommodated in the house and in each sleeping room should be fixed accordiug to the size of the rooms and the facilities for ventilation. The number of privies should be proportionate to the number of people for which the house is to be registered. The receptacles for refuse should be in proper situation, of proper construction and adapted to any scavenging arrangement that may be in force in the place. There should be arrangement for the supply of good water, and if the water is stored in receptacles, they should be conveniently placed and well protected to prevent any fouling.

BUSTEES AND HUTS

Bustee means an area containing land occupied by, or for the purposes of, any collection of huts.

Bustee land means land in a bustee which is let out for the building of huts under an arrangement by which the tenant of the land is the owner of the hut.

Hut means any building no material portion of which above the plinth level is constructed of masonry.

The *floors* of huts are commonly of earth without any damp-proof course or bed of concrete and consequently are

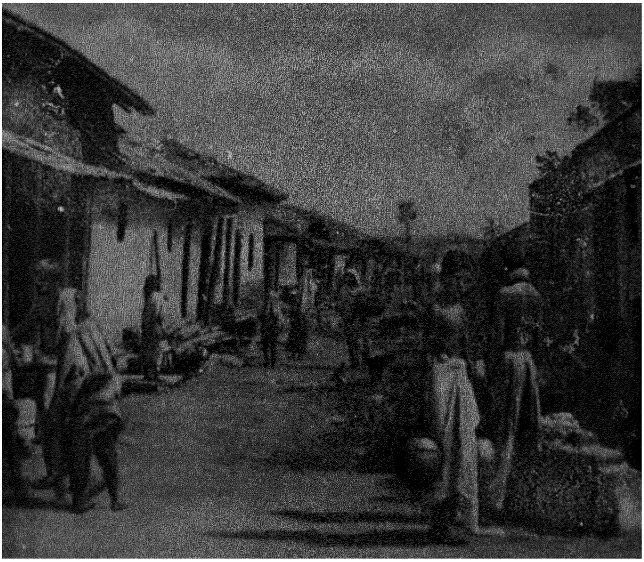

FIG. 27.—A BUSTEE IN CALCUTTA.
Note the accumulation of refuse and irregularity of the huts.

very damp. The floor may also be made either with split bamboos or with *jarool* planks. The plinth should be raised at least 2 ft. or 3 ft. above the level of the centre of the road. This will keep the floors dry.

The *walls* are either of mud, unburnt bricks, bamboo matting plastered over with mud, or corrugated iron or tin. The *roofs* are made either of thatch, paddy straw, *ooloo grass*, palm-leaves, country tiles (*khaprels*), or corrugated iron.

These huts are very unhealthy and efforts should be made to improve them. They should have an open space or courtyard to which each room should open. Each hut should be a detached structure and built in a continuous line with proper arrangements for light and ventilation. They should be of uniform height and not made higher than 16 ft.

In the construction of huts the following points should be attended to :—

(*a*) All huts should be built in a continuous line and should follow the rules prescribed by the Municipality.

(*b*) Mud floors should be dug up and removed every few months; a layer of fresh mud must be laid again. It is better to have cement floors.

(*c*) Each room should have at least two windows 2 ft. square, opposite each other; in the case of one window it should be 3 ft square.

(*d*) Mud walls should be periodically whitewashed.

FIG. 28. A GROUP OF HUTS IN CALCUTTA.
Note the small windows for ventilation.

(*e*) Dirty water and waste food and garbage should not be thrown in the vicinity.

(*f*) The windows and doors should be left open morning and evening for free ventilation.

(*g*) Every hut should have a properly constructed latrine which should be located outside the main hut, preferably in the back yard. It should be easily accessible from behind for proper scavenging.

(*h*) The latrine should have an impermeable floor and must be cleaned daily. The doors and windows must be large enough to allow plenty of fresh air and light.

In this country one of the great difficulties in the way of civic improvement is the irregularity with which the huts are erected in *bustees* without any provision for proper ventilation, scavenging and efficient drainage. The evils attendant upon overcrowding and the aggregation of a large number

of people in these insanitary *bustees* or slums who live in dark, ill-ventilated and damp places are that water-borne and other infectious diseases flourish amongst them. Diseases like cholera, typhoid fever, small-pox and tuberculosis are common; and since these people work in houses of better-class people in various capacities, they carry infection to distant places. Slums are therefore a menace to public health and no amount of sanitary measures will be of any value unless and until the slums are cleared and the housing of the poor is improved. Figure 27 shows a group of huts, the insanitary condition of which is obvious. The roads should, as far as possible, run in parallel lines and the cross roads should intersect others at right angles. The huts should be 6 ft. apart from wall to wall and 3 ft. from eave to eave; and between each row there should be a passage of 9 ft., while the main road should be 16 ft. wide with side surface drains. Dustbins should be placed at a convenient distance, and latrine arrangements made according to the demand of the population.

Bakehouses

In India it is rather exceptional to find a bakehouse built on sanitary principles. The law relating to them being very defective, any room or hut may be converted into a bakehouse. A very common defect is that the floors are not made impervious so that they are productive of serious nuisance as they do not admit of proper cleaning. It is best to have the floors paved or cemented.

It is not only necessary that the process of baking should be carried out with absolute cleanliness, but disease producing germs should not be introduced through infected water, dirty hands, utensils, etc. Before a license is given the following conditions must be enforced in every bakehouse :—(1) The place must be thoroughly washed at least once a day, and no filth or refuse should be allowed to accumulate; (2) the walls, ceiling, etc., should be lime-washed twice a year, and no part of the room should be used for sleeping purposes; (3) the room should be well-lighted and efficiently ventilated, and proper arrangement should be made for the escape of smoke; (4) every one engaged in bakeries should wear clean overalls, and no one allowed to spit in the premises except in proper receptacles provided for the purpose; (5) the table should be clean, impervious and without any cracks; (6) flour not for immediate use should be stored in bags and kept above the ground on some benches; (7) domestic animals should not be allowed in the bakehouse; (8) bread and other products should be kept in covered receptacles, and not exposed to dust and flies; (9) persons suffering from any open sore or other loathsome

disease should not be allowed to work in the bakehouse; and (10) no water-closet, sewer or privy should communicate directly with the interior of the bakehouse.

COWSHEDS AND STABLES

The sanitary condition of cow-sheds and stables in India is very unsatisfactory. Some are nothing but a thatched

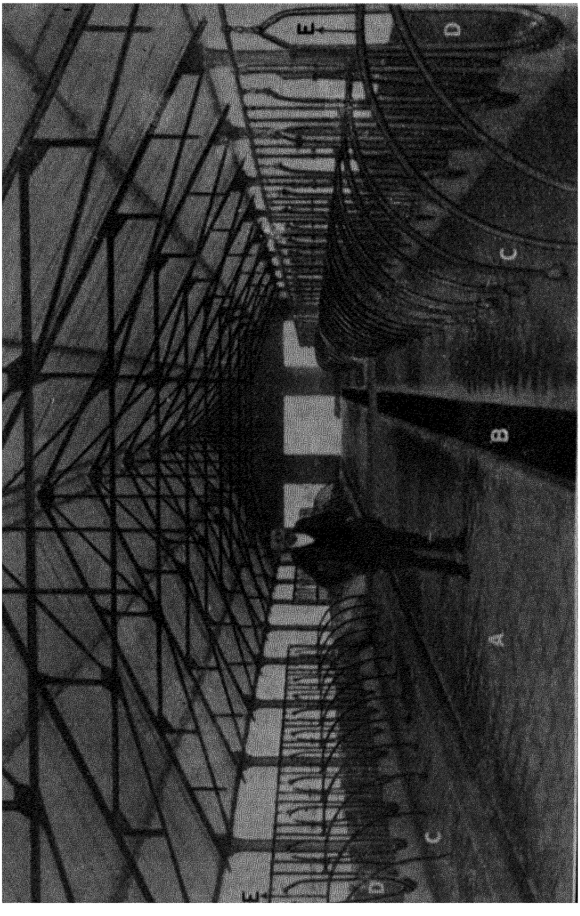

FIG. 29. A MODEL COW-SHED. A, Central Passage, 6 to 7 ft. wide; B, Manure gutter, 2 ft. wide, 10 in. deep; C, Standings or stalls, 5 ft. to 5 ft. 6 in. deep; D, Feeding troughs of cement concrete; E, Divisions between standings made of galvanised steel tubings.

roof built against the wall of the main building or court-yard. Sometimes the cattle is simply kept in one of the rooms of the dwelling itself. The main sources of nuisance in cowsheds are similar to those of horses, but as cows are intended for the supply of milk which is universally used, and since protection of milk from infection is an important consideration, every effort should be made to see that the

water-supply is pure, milk cans and animals are kept clean, the attendants are clean, and any person suffering from any infectious or contagious disease is not allowed to reside or work on the premises. Cow-sheds should be built on a dry ground if available, and must be a separate structure, at least 20 feet from any building and 30 feet from any source of water-supply. The floor should be 6 in. above the ground and made impervious with cement concrete, patent stone, large stone blocks well jointed, or burnt bricks grouted in cement. The stall should be level, and have a slope of 3 in., so that cleansing and swilling can be done easily. The roof should preferably be sloping at an angle of 45°, a space being left between the side walls and the roof in the form of a ridge for proper ventilation. The walls should be low and made either with brick or corrugated iron sheet. All cow-sheds and stables must be provided with drains, made impervious with cement lining, which should carry all urine and wash water to a pit and then into the sewer, or to a movable non-absorbent receptacle of sufficient size which should be emptied at regular intervals. A sufficient number of dust-bins must be provided for the collection of manure and other refuse, which should be emptied and disposed of along with the liquid refuse.

Whenever possible there should be a constant supply of water. Draw off taps should be provided in the shed for animals and arrangement made for attachment of hose pipe for cleansing purposes. If the supply is intermittent the water should be collected in masonry or galvanised iron tanks with a proper cover and overflow pipes and placed on a raised platform. The requirement for each animal should be 12 gals. per day.

Each cow must have a clear space of 8 ft.×4 ft. and a minimum air space of 800 cubic ft.; each horse 9 ft.×5 ft. and each buffalo 8 ft.×5 ft.

When the number of cows stabled is less, a single range stall will suffice provided the space for each cow is not less. A feeding passage 4 ft. wide at the animal's head and a milking and dunging passage 4 ft. 6 in. at the rear should be provided in every cowshed. For more than twenty cows a double range stall is desirable.

Dairies.—Since milk has the remarkable power of absorbing gases and so of deteriorating in quality within a very short time, no milk store or milk shop should be used as a sleeping apartment or for any other purpose likely to contaminate it. Proper provision should therefore be made for the protection of milk against infection. No dairy should communicate with privies or drains, and all milk cans should be steamed or scalded immediately after use. The common custom of carrying milk in open vessels with a handful of straw to prevent splashing cannot be too strongly condemned.

Milk should be carried about in air-tight vessels. All dairies should be properly lighted and ventilated, and provision made for their cleansing, drainage and water-supply.

Eating Houses and Tea Shops

These are quite common nowadays, specially in places like Calcutta and other large cities, and since they play an important part in the economic life of the people, particular attention should be paid to them by the sanitary authorities. They require to be guided by certain regulations, and should be periodically inspected by the municipal authorities or other local bodies. The eating houses are run by all classes of people, but those catering for the poor are in a very deplorable condition, as no attention is paid to the quality of food, general cleanliness, water-supply and disposal of refuse. The premises selected for the purpose should be dry, well-lighted and ventilated, the cooking being done in a separate room detached from the main building having proper arrangement for the outlet of smoke. The floor should be of patent stone or cement so that it can be properly cleaned. There must be an ample supply of good water and all utensils used both for cooking and eating purposes should be properly cleaned and immersed in 2 p.c. hypochlorite solution followed by rinsing in clear water. All food should be kept covered to prevent contamination by dust and flies, and the use of proper cupboards, meat-safes and *doolies* enforced. Tables should be properly cleaned and it would be better to have these marble topped. Arrangements should be made for the reception of garbage, which should be emptied into the public dust-bin or otherwise suitably disposed of. Too often waste food, vegetable particles, ashes and other refuse are collected in a heap in the courtyard or in some corner. Any one suffering from infectious disease, open sore or leprosy should not be allowed in the premises. Persons handling food or the cook should not be carriers of any water-borne disease like cholera or typhoid fever.

CALCUTTA MUNICIPAL ACT, 1923
RULES ON BUILDING SITES AND BUILDING WORKS
Schedule XVII

1. No piece of land shall be used as a site for the erection of a building :—

(1) if the building is to abut on a street, unless the site is of such a shape that the face of the building can be made parallel to the line of the street, or as nearly parallel to the said line as the Corporation may consider practicable :

(2) if the site is within thirty feet of a tank, unless the owner satisfies the Corporation that he will take such order as will prevent any risk of the domestic drainage of the building passing into the tank; and

(3) if the site is a filled-up tank, or has been filled up with

or used for depositing rubbish, offensive matter or sewage, unless the site was so filled up and unless the Corporation has examined the site and granted a certificate to the effect that it is, from a sanitary point of view, fit to be built upon.

Buildings Generally

4. The floor or lowest floor of every building erected or re-erected from the ground-level must be constructed at such level as will admit of—

(*a*) the construction of a drain sufficient for the effectual drainage of the building and placed at such level as will admit of the drainage being led into some municipal sewer at the time existing or projected, and

(*b*) the provision of the requisite communication with some sewer into which the drainage may lawfully be discharged, at a point in the upper half of such sewer, or with some other means of drainage into which the drainage may lawfully be discharged.

6. No new public building or new building which is or is likely to be used as dwelling place or a kitchen or as a place in which any person is, or is intended to be, employed in any manufacture, trade or business shall be erected within six feet of any service privy or service urinal.

8. (1) Except with the sanction of the Corporation, the foundation of a masonry building shall rest on solid ground.

(2) Except with the sanction of the Corporation, the spread of the foundation shall be such that the pressure on the soil, taking into account the load on the floors and terrace roof (if any) shall not be greater than one ton on the square foot.

9. The plinth of a masonry building shall be at least 2 ft. above the level of the centre of the nearest street.

10. Every wall of a masonry building shall be constructed so as to rest upon proper footings having regular offsets and a horizontal spread on each side of the wall of not less than one-half the height of the footings, unless an adjoining wall interferes, in which case the footings may be omitted.

11. The outer walls of a masonry building shall be constructed of brick or some other hard and incombustible substance.

13. (1) Every wall of a masonry building shall have a damp-proof course at or above the level of the ground floor.

(2) Such damp-proof course may consist of sheet lead, asphalt, slates laid in cement, vitrified bricks or any other durable material impervious to moisture.

25. Every room in a domestic building which is intended to be used as an inhabited room—

(*a*) shall be in every part not less than ten feet in height, measured from the floor to the underside of the beam on which the roof rests;

(*b*) shall have a clear superficial area of not less than eighty square feet; and

(*c*) shall be provided, for purpose of ventilation, with doors or windows opening directly into the external air, or into a verandah, and having an aggregate opening of not less than one-fifth of the superficial area of that side or one of those sides of the room which faces or face an open space.

26. Every room in a domestic building which is intended to be used as an inhabited room, and which is constructed over a stable, cattle-shed, or cow-house, shall be separated from the stable, cattle-shed or cow-house by a floor of concrete or other impermeable material.

27. In every domestic building constructed or adapted to be occupied in flats or tenements, the principal common staircase shall be adequately lighted and ventilated upon every storey.

28. The ground floor of every domestic building shall be covered throughout at the height of the plinth, with some impermeable material approved by the Corporation, unless such floor be supported on beams and has a free air-space beneath it.

29. (*1*) The minimum superficial area of every court-yard of a dwelling-house shall be one-fourth of the aggregate floor-area of the rooms and verandahs on the ground floor abutting on the court-yard.

30. (*1*) There shall be, at the back of every domestic building, an open space extending along the entire width of the building and forming part of the site thereof.

Huts

66. Huts in a *bustee* must be built in continuous lines, in accordance with an alignment to be prescribed by the Corporation and demarcated on the ground.

67. When an alignment has been prescribed as above does not correspond with the alignment of a street in the bustee, a passage of at least twelve feet, measured from eave to eave, must be left between the rows of huts abutting on such prescribed alignment.

71. There must be between all huts abutting on a street in a bustee a space of at least three feet measured from eave to eave.

72. Except with the sanction of the Corporation, no hut shall be placed at a greater distance than one hundred feet from the nearest part of a metalled and sewered street.

73. No portion of a hut shall be placed within six feet of a masonry building.

74. No hut used for human habitation shall be placed within six feet of a cow-house, cattle-shed or stable.

76. No hut shall comprise more than two stories or shall exceed eighteen feet in height, measured from the top of the plinth to the junction of the eaves and wall.

77. The floor-level of a hut must be raised at least two feet above the level of the centre of the nearest street or passage and the floor shall be paved with brick-on-edge, cement concrete or some similar material approved by the Corporation.

78. (1) The whole of at least one side of every room in a hut shall either be an external wall or abut on an open court-yard or on an open verandah.

(2) Every room in a hut, which is intended to be used as an inhabited room, shall—

- (*a*) be provided with a doorway of not less than fifteen square feet in area;
- (*b*) be provided with a window or windows opening directly into the external air or into an open verandah, and having an opening of not less than one-fifteenth of the floor area of the room;
- (*c*) have a superficial area of not less than eighty square feet;
- (*d*) have a height of not less than eight feet measured from the floor-level to the junction of the walls with the roof.

CHAPTER VI

FOOD

A FOOD is any substance consumed by man other than drugs and water. Usually by food is meant a substance which, when taken into the body, is able either to build up or repair tissues, or to supply material for the production of heat or muscular work. A true food must therefore be either a tissue builder or a source of potential energy.

Certain articles, *e.g.*, condiments, though strictly speaking they cannot be classed as food, are used as accessories and help in the assimilation of food. Considering the part it plays in the assimilation, salt may also be classed as an important food.

CLASSIFICATION OF FOODS

Foods are variously classified, depending upon their source, into those obtained from the organic kingdom, and those derived from the inorganic kingdom. The former class embraces proteins, fats, carbohydrates and organic acids; while the latter includes mineral salts and water. All these substances are obtained in varying amounts from the animal and vegetable kingdom. Sometimes foods are classified as nitrogenous and non-nitrogenous food, according to the presence or absence of nitrogen.

Strictly speaking, condiments, tea, coffee, etc., are accessories to food. These and the various spices excite the digestive juices and produce a desire for food.

The principal food substances necessary for the maintenance of health are proteins, fats, carbohydrates, salts, water and vitamins. All these substances are present in the animal tissues, and it is therefore necessary that these substances should be present in the foods. Milk contains all the above *proximate principles* of diet and is an example of perfect food for growing children.

Proteins.—These are complex bodies colloid in character excepting in certain leguminous plants where they are crystalline. They are found both in the animal and vegetable food and are most essential for the maintenance of animal life. They are also known as *nitrogenous* or *flesh forming* substances and are composed of

Nitrogen ..	16 per cent.	Hydrogen	7 per cent.
Carbon ..	54 ,,	Sulphur ..	1 ,,
Oxygen ..	22 ,,		

The value of proteins depends on their amino-acid contents.

Milk and meat proteins contain all the amino-acids which enter into synthesis of the protein of the body cells. These are sometimes called *superior proteins* as opposed to *inferior proteins* of corn, wheat and beans. Vegetable protein cannot entirely replace animal protein as some of the amino-acids, *viz.* lysin, cystin, tryptophane and tyrosin, essential for nutrition, are lacking. These are therefore called "proteins of poor biological value." As compared to 97 p.c. of animal protein only 85 p.c. of vegetable protein is absorbed. The primary sources of proteins are from the flesh of animals, eggs, milk and certain seeds and fruits of plants, especially of the leguminous order.

The functions of the proteins are .—

(*i*) They contribute to the formation and repair of the tissues.

(*ii*) They regulate the absorption and utilisation of oxygen, and play an important part in the chemistry of nutrition.

(*iii*) Under certain conditions they form fat.

(*iv*) Under certain conditions proteins supply energy and heat, and may take the place of carbohydrates.

Fats or Hydrocarbons.—These are compounds of fatty acids, *e.g.* palmitic, stearic, etc., with glycerin. They are composed of carbon, hydrogen and oxygen, in which the amount of oxygen is *insufficient* to combine with hydrogen to form water.

One of the great purposes served by fat in the food is to diminish albuminous metabolism, and therefore it is called "albumin sparing food." If flesh alone be given large quantities are required in order that nutrition and waste may balance each other, but if fat be added the demand for flesh is diminished. Fats, however, have an important relation in the body to the production of force and heat, and also to bodily work and bodily temperature. They yield about 2¼ times as much energy as an equal amount of carbohydrate. Unlike proteins the metabolism of fat is independent of the amount of food taken, but is affected by bodily exercise which produces little effect on nitrogenous metabolism. In temperate climates an excess of fat is usual in the diet of those who do hard work, where the fat is more or less directly utilised as a source of energy. Fats are great heat producers, hence the desire for fats under arctic conditions. But when there is excess of fat in the diet of sedentary persons, part of it is unabsorbed and passes out with the fæces, but a large amount is stored up in the body. Closely related to fats are the lipoids which are present in the animal tissues in the form of lecithins and phosphatides. The former occurs in large amounts in nervous tissues and is found in the yolk of eggs. Cholesterol though a monohydric alcohol is ranked with lipoids and is present in all cells and nervous tissues. Its function in the body is not clearly understood.

Carbohydrates.—These are compounds of carbon, hydrogen and oxygen, in which the oxygen is present *in the proportion required* to form water with the hydrogen. During digestion, starch, cane sugar, dextrose, and milk sugar are transformed into grape sugar or glucose before they are absorbed, and in this form they are more easily digested than the fats or proteins. The excess of sugar is stored up in the liver and muscles as glycogen. The glycogen of the muscle disappears in proportion to the work done, and prolonged muscular work especially during starvation may wipe out the entire store of glycogen in the body. The oxidation of sugar therefore furnishes energy which by the machinery of muscles is utilised to do work. This oxidation plays an important part in the supply of heat needed by the body. Each gram of sugar yields 4·1 Calories of heat, and since carbohydrates form the major portion of our diet and are easily oxidised, they are an important factor in the maintenance of animal heat.

The carbohydrates therefore play the same role as fats in food, being sources of heat and energy, and are more easily taken up into the system than any other class of food. They are also a source of fat, but in ordinary diets they are utilised immediately as sources of energy.

Vegetable Acids.—Although these are not, strictly speaking, foods, they are necessary for the preservation of health; the chief ones being tartaric, citric, oxalic and malic acids. Vegetable acids are mostly derived from fresh fruits and vegetables, and by forming carbonates in the system preserve the alkalinity of the blood and other fluids. By oxidation they help the body to maintain a certain amount of heat and energy.

Mineral Salts.—These salts form an essential part in the composition of living matter and maintain the normal osmotic pressure in the fluids and tissues of the body and play an important part in the regulation of the acid-alkali balance. The chief mineral elements in the body are calcium, sodium, potassium, iron, magnesium, manganese, phosphorus, sulphur, iodine, chlorine, silicon and fluorine. Of these calcium, potassium, sodium, iron, manganese, copper and magnesium exist in the body in large quantity and are the most important, and are the *alkali forming elements*. Phosphorus, sulphur and chlorine are the *acid forming elements*. The normal blood has a *p*H range of from 7.3 to 7.5 and life is incompatible when the *p*H of blood is below 7.0 or above 7.8. The maintenance of the *p*H at its normal level in the blood and tissues is very important and is regulated by the carbonates and the alkaline phosphates which form the alkaline reserve, while the carbonic acid and the phosphates and the proteins, the acid reserve. These act as "buffers" and tend to neutralise any attempt to change the actual reaction. Of the

salts, sodium chloride or common salt occurs in all the tissues and fluids of the body. It helps the formation of hydrochloric acid of gastric juice and bile salts, and is absolutely necessary for existence. In animal experiments it has been found that a complete salt-free diet produces death more rapidly than starvation. In man a salt-poor diet reduces the excretion of salt by the kidneys to the level of salt intake, consequently there is little danger of chloride depletion. Under certain conditions however a salt-free diet is used in therapeutics. A large part of it is taken in meat, bread, etc. Every cell in the body contains phosphorus, therefore it is essential for the multiplication of cells and the growth of the body. The phosphates of sodium and potassium are important salts and regulate the reaction of body fluids and tissues, control the osmotic pressure and consequently the distribution of fluids. Sodium carbonate and bicarbonate are also found in the plasma. They are taken in small quantities with the food and are partly formed in the body by the decomposition of the salts of the vegetable acids. They carry CO_2 from the tissues to the lungs. Calcium phosphate is essential for the development of bones and is very important for the young. Calcium salts also play a most important role in connection with the irritability of muscle and nerve. The best source of lime salts is milk, and next to milk, eggs. Rice is also an important source of calcium, so are pulses, fruits and green vegetables. The minimum requirement of calcium in the body is 0.45 gm., and a diet should furnish at least 1 grm. of calcium oxide (which is equivalent to 0.67 gm. of calcium) daily. It is required in much greater amount by children and during pregnancy. But most of the calcium of food is lost during cooking, *e.g.* milk when boiled loses much of its calcium, and the scum takes up and retains the calcium phosphate. Iron is an essential element of hæmoglobin, and therefore of the red blood cells. It is also found in the muscles and in other tissues in minute quantities where it plays an important part in the oxidation and catalysis of enzymes. An adult man contains about 3.0 to 3.5 grms. of iron, of which 2.4 to 2.7 grms. exist in the form of hæmoglobin. About 20 mgrms. are excreted daily, and this loss is replaced by the iron of the food, and a minimum of 6 to 12 mgrm. is required to maintain this equilibrium. Foods containing iron are liver, red meat, eggs, pulses, whole cereal grains, onions, lettuce, etc. Iodine is found in the thyroid gland in the form of *thyroxin* which regulates metabolism. It is said that simple goitre is due to lack of iodine in the water and soil of goitrous regions. It occurs in the sea, and sea fish and cod-liver oil are rich in iodine. Ordinarily green vegetables and fruits contain enough iodine for the needs of the body. The minimum amount of iodine required by an adult male is about

45-millionths of a gramme, and by a child about 150th-millionths.

All these mineral substances are introduced into the body as constituent parts of the various ordinary articles of human food, animal or vegetable, with the exception of common salt, which is usually added to various foods in greater or smaller amount in addition to what they may themselves contain.

Vitamins.—Observations made by Funk and others show that in addition to the different proximate principles, there are certain accessory materials that are necessary either because they play an important role in the synthesis of the body, or influence in some indirect way the normal direction and character of the metabolism. It has been shown that polyneuritis is produced in fowls by a diet exclusively of polished rice, *i.e.*, rice from which the outer layers of the grains have been removed. If however the polishings are restored to the diet, the condition disappears. It is believed that the polishings contain some material essential to the body metabolism. They are as a rule present in raw foods and are deficient in cooked foods. Certain foods manage to retain their vitamin to some extent even after cooking.

These accessory substances are essential to normal growth and health. The part they play in the metabolism is not clearly understood, and since very minute quantities are required for the maintenance of health, it has been suggested that they stimulate the production of hormones and are not directly concerned in the nutrition of body cells or the general growth of the organism.

Vitamins exist in the foods in very minute quantities, and a vitamin free diet gives rise to certain diseases, generally known as deficiency diseases, and may even cause death. Rickets, pellagra, scurvy, beri-beri, xerophthalmia or keratomalacia, osteomalacia are some of the diseases caused by the lack of vitamins in the food. Green vegetables and fruits are rich in vitamins, and both man and animals obtain their vitamins from these sources. Vitamins are produced only in plants from which they pass directly with vegetable foods, and indirectly with animal foods, into the system.

Drummond has shown that the whole fat-soluble vitamins are contained in the 1 p.c. of the non-saponifiable matter in cod-liver oil. Half of this active residue is cholesterol and is inactive. Fractional distillation of the remainder under low pressure shows that the whole of the active portion is contained in the fraction boiling between 180° to 200° C. This active fraction consists very largely of an unsaturated alcohol, and contains only the elements carbon, hydrogen and oxygen.

Vitamins have been classified into :—

(*a*) Growth Promoting Vitamin or *Fat-soluble A*.

(*b*) Antineuritic Vitamin or *Water-soluble B_1*.

(*c*) Antiscorbutic Vitamin or *Water-soluble C.*
(*d*) Antirachitic Vitamin or *Fat-soluble D.*
(*e*) Anti-sterility Vitamin or *Vitamin E.*
(*f*) Pellagra Preventive Vitamin or *Vitamin B_2* or *G.*

(*a*) *Growth Promoting Vitamin or Fat-soluble A.*—The deficiency of this vitamin retards growth and lowers resistance, either local or general, to bacterial infection, causes xerophthalmia or inflammation of the eye and night blindness, and increases susceptibility to various lung, skin and other infections. Its absence also causes paralyses of various types from demyelination of the spinal cord; and Mellanby has suggested that the paralysis associated with famine, *e.g.* convulsive ergotism, may be the result of the absence of this vitamin. Mellanby has further shewn that its deficiency causes pyorrhœa alveolaris in dogs. Recent work however appears to throw much doubt on the anti-infective value of this vitamin. It does not appreciably lower the incidence of common colds and related catarrhal conditions, nor does it modify in any apparent manner the outcome or the course of pneumonia, and there is reason to doubt whether it lessens the risk of sepsis and other complications in child-birth (Drummond, *Journal of State Medicine, Jan.*, 1934). Any effect which may follow its use is possibly indirect due to general improvement of health and vigour. Its relation to the formation of urinary calculi was studied by McCarrison who observed that a deficiency of this vitamin and of phosphates in the diet together with the presence of an excess of calcium and some unknown toxic substances found in certain cereals encouraged the formation of stone so common in certain parts of India.

Vitamin A is closely related chemically to *carotene* which is converted into it in the body. In fact it is considered as the degradation product of the plant pigment *carotene* produced in the liver from *Lipochrome.* It is of interest to note that cod-liver oil though rich in this vitamin contains none of this pigment. Pure carotene has been adopted as the standard of vitamin A activity; 0.001 mg. being designated as a vitamin A unit. The amount is estimated by the colour reaction with antimony trichloride.

The main sources of this vitamin are (*a*) certain fats of animal or vegetable origin, and (*b*) chlorophyll in green vegetables. It is preserved in these vegetables even when dried. It is found in abundance in cream, butter, beef-fat, cod-liver oil, halibut liver oil and other fish oils, mammalian liver and yolk of eggs. Milk does not lose this vitamin by boiling or pasteurising, but when evaporated by vacuum or aeration methods it is destroyed. Vegetable oils contain very little vitamin A.

(*b*) *Antineuritic Vitamin or Vitamin B complex.*—Vitamin B is now considered to contain six separate entities of which

the important ones are antineuritic vitamin (B_1 or F) and pellagra preventive vitamin (B_2 or G). The antineuritic factor is supposed to be related to adenine, a purin base, which is converted on exposure to ultra-violet light into a substance having the same property as this vitamin. This view however has not been accepted by many workers. For standardization, 10 mg. of a concentrate prepared from rice polishings have been designated as one international unit.

One of the chief effects of partial deficiency of this vitamin is the failure of growth and production of intestinal stasis resulting in the retention in the bowels of the putrid food residue and absorption of the products of putrefaction. The absence of vitamin B_1 or F causes beri-beri in man and analogous disease in animals. This assertion has of late been challenged by Drummond and Woollard (*Journal of State Medicine, Jan. 1934*) who hold that the symptoms of polyneuritis are really due not to the absence of vitamin B_1 but to partial starvation as a result of loss of appetite which is characteristic of the absence of this vitamin. They further hold that the degeneration observed in nerves in polyneuritis was in all probability due to faulty histological technique. Vitamin B_1 is found to some extent in all natural food-stuffs, specially in the germ and outer layers of cereals and legumes, in yeast and nuts. It is also present in tomatoes, oranges, green leaves, fish, meat, eggs and milk. It is absent in white bread but is present in whole-meal bread. Marmite is a valuable source of vitamin B_1 and is extensively used in the treatment of pernicious anæmia. But since dried yeast, or watery extract of yeast, is therapeutically inactive as a source of extrinsic factor, but autolysed yeast products are active, it has been suggested that the anti-anæmic factor is manufactured during the process of autolysis which possibly is a protein breakdown product of the nature of a polypeptide. It is probable that the large proportion of chronic disorders of the alimentary tract can be attributed to the deficiency of vitamin B_1 in the diet. The question of quantitative relation between the amount of vitamin B and the amount of protein, fat and carbohydrate in the diet has received a good deal of attention. It has been pointed out that to promote normal growth the ratio of protein to vitamin B should be kept constant at about 5 of protein to 1. The antineuritic vitamin is slightly affected by high temperatures. It is however less stable than vitamin A, although it withstands boiling for a short time and is destroyed only slowly in acid or neutral solution even when subjected to a high temperature. At 100° C., which is comparable with ordinary cooking process, the antineuritic property of wheat germs is slightly diminished, and at 120° C., which is attained during the sterilisation of human food, as in canning, destruction is much more rapid.

(c) *Antiscorbutic Vitamin or Water-soluble C.*—This is necessary for the prevention of scurvy and is found in fresh vegetables and animals. It has been isolated in a crystalline form which has been named hexuronic acid or ascorbic acid, originally found in the cortex of suprarenal gland. Its richest sources are cabbages, turnips, lemons, oranges and tomatoes. Milk and meat possess a definite but low antiscorbutic value. The antiscorbutic vitamin differs from the antineuritic one in its distribution and properties, as well as in the nature of its influence on nutrition. It is less wide-spread and is more sensitive to heat and drying than the antineuritic one. Tinned foods which have been raised to a temperature of 120° C. lose their antiscorbutic properties. It has also been shown that although dried pulses contain no antiscorbutic principles while still dry, the antiscorbutic elements develop in 48 hours if they are moistened, kept warm and allowed to germinate. All dry foodstuffs are deficient in antiscorbutic vitamin. The tissues of fresh vegetables dried at a low temperature, or their expressed juices preserved in the cold rapidly lose their antiscorbutic property.

(d) *Antirachitic Vitamin or Fat-soluble D* (Calciferol).—McCollum has pointed out that this vitamin, which was considered the same as fat-soluble A factor, is a separate entity. It can be produced by the exposure of ergosterol to ultraviolet light and is now obtainable in pure form as white, needle-like crystals, which has been named *calciferol*. Webster and Rosenheim have pointed out that *ergosterol*, a highly unsaturated sterol, is the direct precurser of vitamin D, and that this substance is transformed into vitamin D when the skin is exposed to direct sunlight. Moreover Steenbock and Drummond have shown that substances which were previously inert become activated and possess antirachitic virtue when exposed to ultra-violet rays. Vitamin D is more resistant to heat and oxidation than vitamin A. Deficiency of this vitamin retards absorption of calcium from the intestine and thus causes rickets. It corrects improper balance in the calcium and phosphorus intake, and the greater the disproportion or defect in these elements, the more important is the role of this vitamin in the prevention of rickets. Even when the calcium phosphorus balance is good and the supply adequate, its absence will result in the production of imperfectly calcified bones and teeth which are rectified by the supply of this vitamin.

Cod-liver oil and halibut liver oil contain vitamin D in very large amounts. Butter fat has a much greater effect on xerophthalmia than cod-liver oil, whilst the antirachitic power of cod-liver oil is far superior to butter fat. The antirachitic property of cow's milk can be increased by exposing the cow to sunlight, but the growth promoting property remains the same.

(*e*) *Anti-sterility Vitamin or Vitamin E.*—Evans has shown that there is a third fat-soluble factor necessary for reproduction. Its absence in the food causes death of the products of conception. These observations were made on female rats and it has not been proved yet whether it has any effect on human beings. It is present in most animal tissues but not to a high degree and is not present in cod-liver oil. Milk fat also contains very little of this vitamin. It is found in abundance in the embryos of seeds and green leaves, chiefly lettuce, alfalfa, peas, oats corns and wheat germ oil.

(*f*) *Pellagra Preventive Vitamin, Vitamin B_2 or G.*—This is vitamin p-p of Goldberger. Animals deprived of this factor shows retardation of growth and a group of symptoms resembling pellagra. Although it is generally admitted that pellagra in man is due to faulty diet, there are strong indications that several factors may jointly operate to produce the condition and one of these is vitamin B_2 or G. In fact Aykroyd (*Biochemical Journal, 1930*) has pointed out that although rice, millet and maize are deficient in vitamin B_2, human pellagra is associated with the consumption of maize only (*see* pellagra, page 162). It is believed that vitamin B_2 is closely related to the anti-anæmic factor contained in the liver.

Water.—This is an important article of diet and forms 64 per cent. of the body weight. The daily loss from the system is about 100 oz. Water is necessary to compensate for the losses caused by the excretory organs, and for the repair of the various fluids and of the solid organs of the body into whose constitution it greatly enters. It is also a vehicle for the solution and dilution of solid foods whereby they are more easily digested and assimilated. The amount of water needed by the body depends on various circumstances, especially on bodily temperature and bodily labour. The greater the functional activity of the bodily organs, the more is the demand for water. The temperature and humidity of the air, the nature and amount of solid food taken, also increase the necessity for the intake of water. The demand for water is indicated by thirst. An insufficient supply leads to disturbances of circulation and of the heat regulating mechanism, and to retention of products of metabolism. Free drinking of water promotes the circulation of fluids, accelerates albuminous metabolism, and increases the activity of the kidneys with free secretion of the urine.

Quantity of Food Required in Health

The amount of food necessary depends upon various factors (see below), but it is generally considered that a man of average weight and engaged in moderate amount of muscular work must be supplied with food which should contain sufficient energy with an average 3,000 Calories, and must provide

for the upkeep and repair of the tissues of the body. A man doing sedentary occupation for 16 hours and remaining in bed for 8 hours requires 2,170 and a farmer doing active outdoor work needs 3,500 large Calories respectively. Whereas 1700 Calories are required for the upkeep of the basal metabolism of an adult, *i.e.* the metabolism necessary to maintain the essential functions when the person is in a state of complete mental and physical rest. It is the smallest energy output compatible with health. It has been found that the basal metabolism of an adult is approximately 40 calories per hour per square metre of body surface. It is 37 for women, 44 for boys above fifteen and 50 for boys of twelve to thirteen. Mukherji (*Indian Journal of Medical Research, Jan.* 1931) has pointed out that the basal metabolism of Bengali young men was – 13.3 p.c. (Aub and Dubois standard), while Miss Mason found – 18 p.c. in South Indian women.

Standard dietaries are dietaries based upon the results yielded by the physiological experiments, but they have a very limited application and are useful only in furnishing one with some data of the amount and kind of food to be given to a healthy person doing a moderate amount of work. This is especially important in connection with the management of poor houses, schools, jails, and the like. In the case of individuals however, certain modifying factors, such as age, sex, height, build, work, etc., have to be considered.

Age and Sex.—Building material, fuel and muscle food are more needed by children than adults, because they have got to add to their tissues by growth in addition to keeping them in repair. Women require relatively less food than men on account of the lighter nature of their work, and also perhaps from their possessing a slower metabolism.

Just as childern require a large amount of food, so with the aged the reverse holds good. At this age the power of assimilation is on the wane, and bodily activities on the decline, and so the diet should be smaller than that of middle age.

Height and Build.—The amount of food required varies with the body weight and the extent of the body surface. A heavy man requires more food than a light one. Again, more heat is lost if the body surface is great and consequently a larger supply of fuel is required.

Work and Rest.—In ordinary life the amount of food needed depends more upon the muscular activity than on any other factor. It has been shown that a greater performance of bodily labour calls for an additional supply of proteins and carbohydrates in the food. On the other hand, during complete bodily rest, as during illness, the demand for potential energy may fall to 2000 Calories or less per day. The work done is measured in foot-pounds or kilogrammetres and these can be converted into Calories.

One Calorie is equal to 426.6 kgm. or 3086 ft. pounds; and one kilogrammetre is equal to 7·233 ft. pounds. A man working about eight hours a day does work approximately about 10,000 kilogrammetres per hour, or about 200 Calories per day.

Mental work does not increase bodily waste to any appreciable extent; quality and easy digestibility are more needed by brain workers than mere quantity.

Climate.—Owing to the greater loss of heat more food will be required in cold climates than in temperate ones, and more in temperate climates than in the tropics. In very hot weather the appetite is lessened and less food is taken and consequently there is some loss of weight. In cold climates and in winter the heat-supplying foods, especially those rich in fat, should be increased, while under opposite conditions there should be more carbohydrates and less proteins and fats.

The Relative Value of Foods

The relative value of different foods must be considered on chemical and physiological grounds.

The *chemical value* of food is estimated by the results of percentage analyses. But the nutritive value of food cannot be judged from its chemical composition alone. While food with a small percentage of nutriment cannot be regarded as a valuable article of diet, a high chemical value alone does not imply suitability to the needs of the body.

The value of food from a *physiological* standpoint depends upon its digestibility and absorbability.

Digestibility of food.—This depends on two factors:—

1. The food must be in a fit state to be digested.
2. The physical and chemical conditions in the body must be appropriate.

A mixed diet is easily digested. Food accessories like condiments, etc., also help digestion. Palatability of food is not simply a gratification of the sense of taste and pleasure. An appetising food, or even the idea of it is sufficient to make the mouth water, *i.e.*, increases the flow of saliva, and at the same time produces in the stomach what has been termed by Pawlow "appetite juice." Moreover, the increased production of saliva in its turn tends to augment the secretion of gastric juice, which stimulates the duodenal mucous membrane and leads to the production of the hormone *secretin*.

Absorbability of Food.—The absorbability of the food in the intestines must be distinguished from digestibility in the stomach. By *digestion* is meant the production of simpler bodies which are presented for absorption, but the actual amount of absorption depends upon certain physical

factors, *e.g.* osmosis, diffusion, etc. Therefore a food that is easily digested is not necessarily that which is completely absorbed, and *vice versa*. Carbohydrates and fats are more completely absorbed than proteins, and animal proteins more readily absorbed than the vegetable ones. It should be noted, however, that part of the food should remain in the intestines to act as a "ballast" to stimulate peristalsis.

Time for Taking Food.—A diet with all the proximate principles may with advantage be taken three times a day. It takes about 4 to 5 hours to digest an average European diet, and 7 to 8 hours an average Indian one. But in either case this varies with the kind of food taken. During youth, when the digestive functions are comparatively active and rapid, the intervals should be shorter than during adolescence. Indians as a rule take two principal meals, the breakfast in the day, and the dinner at night. A morning meal is always necessary, for so long a fast after the last meal at night under the modern conditions of life is rather exhausting and injurious; for the body becomes more susceptible to morbid influences, especially to cold and other infections. There should be a sufficient interval between the last meal and bed time. Regularity in the time for taking food is important. In some cases the desire for food occurs with all the regularity of the clock, and if the food is not taken at that time the appetite disappears.

The Fuel value of Food.—The exact changes or the complicated metabolic processes that food undergoes in the body is not well understood, but the food is transformed into simpler molecules accompanied by heat and energy. The amount of heat and energy which each food can impart to the body if it is completely digested and utilised can be ascertained by a calorimeter. A calorie is the amount of heat required to raise one gram of water 1°C. This unit is designated as a small calorie to distinguish it from a large Calorie (C), that is, the quantity of heat necessary to raise 1 kgrm. of water to 1°C. The large Calorie is equal to 1000 small calories. It has been shown that the heat value of 1 grm. of protein and 1 grm. of carbohydrate is 4.1 Calories each; while that of 1 grm. of fat is 9.3 Calories. Calculating on this, the heat value of a diet consisting of 100 grm. of protein, 100 grm. of fat and 500 grm. of carbohydrate would be :—

$100 \times 4.1 + 100 \times 9.3 + 500 \times 4.1 = 410 + 930 + 2050 = 3{,}390$ Calories.

Cooking of Food

Cooking answers most valuable purposes in connection with food. It increases the palatability of food and enables it to be more readily masticated and easily digested. By improving the appearance of the food it renders it more

appetising. A number of vegetable products that would be too hard for digestion are rendered softer, and protein foods are made more palatable and digestible. Certain pathogenic microbes with which the food may be infected are killed by this process.

The digestibility and palatability of vegetable foods depend largely on the manner of cooking; the object being to soften and rupture the cellulose fibres and to liberate the starch granules. A large proportion of mineral salts contained in the vegetable foods being soluble in water is lost when they are cooked by boiling. Vegetables contain so much water that they can be cooked in their own juices, or better by steaming. Potatoes, roots, green vegetables, etc., are boiled in a bath of water, and this involves a great loss, as the bulk of the valuable mineral salts are drained away. Boiling of all operations of cookery is that which calls for the most careful judgment, and that method of boiling which causes no loss at all is the best, a result only attainable by cooking in dry steam.

There are at the present time many different kinds of apparatus for steam cooking, but the parent of them all was the cooking pot invented by Captain Warren, and all steam cookers are more or less built upon the Warren principle. The saving thus effected is proved by the fact that a cooked joint of meat with gravy will weigh just the same as the raw joint when put into the cooker.

Cooking, therefore, is almost always an advantage, but there are instances where the reverse is the case. Oysters contain a digestive ferment sufficient to digest themselves but when cooked not only is this ferment destroyed but the flesh becomes tougher.

Methods of Preserving Foods

Both animal and vegetable foods undergo fermentation or decomposition after some time from the effects of micro-organisms, which may be present in the food or may find their way from without. Since these foods give rise to symptoms of poisoning and cannot be taken without some harmful effects, preservation of milk, meat and other perishable foods is often resorted to. The importance of preserving foods in such a way as will keep them fresh and wholesome, and at the same time retain their nutritive value cannot be overestimated. The usual methods are drying, salting, smoking, cold, canning, and the use of chemicals. These methods are based on our knowledge of bacteriology and the causes of decomposition. Whatever method is used, the chief object is not only the inhibition of the activities of the organisms already present, but also prevention of contamination by extraneous organisms.

Heat and Canning.—This is the most common method of preserving food. Although boiling kills most organisms, boiled articles may be contaminated by outside bacteria. In the process of canning not only the food material is boiled and sterilised, but it is effectively sealed to prevent contamination from outside. The temperature and duration of exposure should be enough to prevent bacterial growth without impairing its attractiveness. Of all the preservatives canning is the best method, and any kind of food may be preserved in this way. This is done by heating the can to drive out the air and then sealing it ; when the can is cooled a vacuum is formed. In successful canning the manipulation of the food prior to sealing of the can should be cleanly and expeditious so as to restrict the bacterial population to minimum. After the vacuum is formed the flat sides of the can should become concave or pressed tightly against the meat. The interior of the can may be plain or lacquered which diminishes the action of the acid food upon the metal of the container. Canning interferes with the antiscorbutic vitamin, but less than occurs in ordinary cooking, while vitamin A is capable of withstanding any temperature if the air is sufficiently exhausted. Vitamins B_1. B_2, D and E are not destroyed.

Drying.—Since moisture is required for the growth of micro-organisms, drying is a common method of preserving certain foods, of which biscuits and dried milk are familiar examples. Meat is not so well suited for drying, as it loses much of its natural flavour. The antirachitic and antineuritic vitamins are not affected by the process of drying although the antiscorbutic vitamin may be diminished by it.

Smoking.—Meat and fish are generally preserved by smoking. This is done after a preliminary salting. During the process of smoking the articles become dry and impregnated with pyroligneous products of smoke which exert some germicidal effect. But this does not penetrate deep, and since smoked meat is eaten without further cooking, the possibility of the presence of some parasites and the products of decomposition should not be lost sight of.

Salting and Pickling.—Salt is commonly used for the preservation of meat and fish. Salting and pickling are also done with brine, vinegar or some weak acid. Boric acid or sodium sulphite are sometimes added to brine. Prolonged pickling kills *trichina* and many bacteria, but salting really prevents the growth of germs and does not kill those present. Pickling makes the meat tough and less digestible.

Sugar in the form of syrup is also used for preserving fruits, and has the same action as salt or vinegar.

Cold.—Since a temperature below the freezing point of water prevents the growth and multiplication of most bacteria, cold is largely used for preserving food. Most

animal parasites die in cold storage, and cold reduces quantitatively the number of harmful bacteria. From a sanitary point of view cold is one of the best methods of preserving food. It does not alter the taste nor affect the natural flavour, but is only a temporary measure, and since the bacteria are not killed they grow and decomposition begins as soon as the temperature rises above 10°C. It is largely used in preserving fish and meat. Considerable quantities of frozen meat are exported from America, New Zealand and Australia. Meat, eggs, fish, fruits, and even milk can be preserved in cold storage for long periods. The usual method of producing cold is by rapid evaporation into the gaseous state of liquid ammonia. The resultant cold brine is made to circulate in pipes through the different chambers of the storage.

Chemicals.—Some antiseptics are used for the purpose of preserving food, but as a matter of principle the use of chemicals should be avoided. Sugar, salt and vinegar are not classed as chemical preservatives although their actions are the same as that of any other chemicals. The common chemicals are benzoic acid and benzoates, boric acid and borax, formaldehyde, salicylic acid, sulphites, hydrogen peroxide and sodium bicarbonate. Preservation of milk, cream, butter and margarine by the use of chemicals has been prohibited by law in Britain. In fact except benzoates and sulphites, which are allowed only in the case of special articles like fruit pulp, etc., all preservatives are forbidden in Great Britain.

Diseases Connected with Food

Articles of food when exposed to the open air undergo all sorts of contaminations ; hence it is absolutely necessary that foods, whether in the shop or in the house, should be kept in suitable receptacles in such a manner as will prevent the risk of contamination from dust, flies, and other insects causing diseases like typhoid fever, paratyphoid fever, cholera, etc., but these are not included under the term acute food poisoning. There are again other diseases like scurvy, beri-beri, pellagra, ergotism, lathyrism, etc., connected with the consumption of certain foods, and not due so far as is known to any parasites introduced with food.

The different varieties of food poisoning are grouped as follows :—*

1. *Food Allergy.*—Some persons owing to an inherent or acquired idiosyncrasy are sensitive to certain kinds of food and produce symptoms allied to anaphylaxis. These individuals cannot take certain foods without producing some

* Savage : *Acute Food Poisoning.* Medical Annual, 1926.

inconvenient symptoms. These may be gastro-intestinal, urticarial or asthmatic. The majority of foods which produce these symptoms are protein in nature, and are eggs, fish, cheese, pork, shell-fish, prawns, etc.

2. *Bacterial Infection.*—This may be due either to infection with living bacteria or to the action of the toxin which survived the process of cooking. In bacterial infection the symptoms appear after a definite incubation period of about eight hours, but when due to toxin the symptoms appear rapidly. Food infection is an acute condition and produces symptoms of gastro-intestinal irritation, *viz.*, nausea, vomiting, abdominal pain, diarrhœa and often collapse.

(*a*) *Botulism.*—This variety of food poisoning is of great importance because of the high incidence of mortality. The organism responsible is *B. botulinus*, a sporing, obligate anaerobe with fairly definite characters. It produces true extra-cellular toxin to which the symptoms are due. The bacillus and its spores are widely distributed in nature. It lives normally in the soil, and by soil contamination food may become infected, specially fruits and vegetables. The spores themselves are harmless unless they are under conditions which allow them to germinate and so produce the toxin. As a rule the toxin is not produced in the foodstuff, but tinned products which have become contaminated and then kept warm (68° F.) afford a suitable medium for toxin production. Fortunately however it is destroyed at a temperature of 175°F.

The organism is carried through different foods. In Germany the attack followed the use of sausages and other meat foods; in U.S.A. canned vegetables and canned fruits; while the Loch Maree outbreak was due to an infected glass jar of wild-duck paste.

Man is extremely susceptible to this toxin and death has taken place after eating one-half of an olive. The symptoms are characteristic and are quite different from other types of food poisoning. The symptoms first appear generally 12 to 24 hours after ingestion of the infected article, but may appear earlier or may be delayed. In some instances the symptoms appear within six hours of eating the infected food. As a rule the symptoms are entirely nervous in character, the gastro-intestinal symptoms, *viz.* vomiting and diarrhœa may occur but are usually slight and transitory, but constipation is common and is due to paralysis of peristalsis. Distorted vision, diplopia, 3rd nerve paralysis, ptosis and weakness and paralysis of accommodation generally follow. Death occurs from failure of heart and respiration in 4 to 6 days.

(*b*) *Salmonella Food Poisoning.*—The salmonella bacilli form a well-defined group which are culturally closely allied. Of the various types, *B. enteritidis* (Gaertner), *B. aertrycke*,

B. typhimurium, are the commonest causes of food poisoning. They are non-sporing organisms and are not resistant to heat, but all the food poisoning types produce endotoxins and are highly resistant to heat and can withstand a temperature of about 100° C. without loss of toxicity.

It is not exactly known how these organisms gain entrance into the incriminated food. They are not natural inhabitants of human or animal intestines. It is possible that infection occurs from specially infected animals, cows, pig and rats. The latter frequently suffer from salmonella infections. The infection is carried indirectly, through direct handling, infected knives, flies, etc. The organisms which are carried by human carriers are B. paratyphosus B., but they do not cause food poisoning. Salmonella organisms are not excreted by men for more than a few days after infection.

(*c*) *Staphylococcus food poisoning.*—Six outbreaks have been reported (*Journal of American Medical Association*, 1931) after eating a layer cake. The symptoms were vomiting, diarrhœa, abdominal pain. The cake contained yellow hæmolytic staphylococci. Sterile broth filtrates of this strain produced the symptoms in human volunteers. In this type the incubation period was four hours, and the symptoms though severe no deaths have been recorded.

The view that food poisoning may be associated with putrefactive changes in the food, a condition known as *ptomaine poisoning*, is not accepted. There is no evidence of any value that putrefactive changes in meat or other food ever caused an outbreak of food poisoning. Ptomaines are late protein degradation products never found until the food is far too nasty to eat.

Food may convey foreign poisons, which may be metallic poisons, or chemicals used as adulterants. The presence of certain specific or parasitic diseases such as tuberculosis, trichinosis, etc., may impart the disease, when the flesh or milk of such animals is eaten. Foods may not be poisonous in themselves but may have an injurious effect on persons with weak digestion.

Investigation of outbreaks of Food Poisoning.—In investigating an outbreak of food poisoning the student should remember that the line of investigation to be adopted will vary according to the nature of the outbreak. There is always some interval between the ingestion of the food and the first appearance of the symptoms, and much valuable information can be gathered by a careful study of this interval. When the infection is due to some preformed toxin, as in poisoning by tinned foods, the symptoms appear rapidly and the bacteriological findings are negative. On the other hand when the infection is caused by ingestion of living infective bacilli the incubation period is of longer duration since sufficient

time must elapse before the organisms can manufacture enough toxins to produce any symptoms. When the outbreak is caused by a mixture of bacilli and toxins the incubation period is variable depending upon the amount of toxin ingested and the degree of bacterial contamination of the food. Noting these facts proceed to make a complete list of cases and note particulars of individual cases of illness and vehicle of infection. Then make a detailed investigation of the extent of the outbreak and record all the articles of food consumed, and then ascertain by a process of exclusion foods likely to have caused the outbreak. Secure samples of implicated foods (this must be from the actual portions remaining over) and obtain all possible information as to their source and possibilities of their contamination. If any case proves fatal, post mortem materials from the spleen, liver, small and large intestines, and the kidneys should be taken and bacteriologically examined, when valuable information on the nature of the infection may be obtained. Specimens of fæces and vomit passed by the patient during the acute stage often give positive results. Laboratory investigation should consist in examination of the suspected foodstuffs; their appearance, smell, chemical reaction and any deviation from normal should be noted. Make both aerobic and anaerobic cultures followed by feeding and inoculation tests. Finally samples of blood from the victims taken after one week may give agglutination test with known cultures of organisms.

Excess of food.—If an excess of food is taken, the organs concerned in the metabolic processes have too much work thrown upon them, and if they are able to perform the task the blood becomes surcharged with oxidisable matter. The overloaded condition of plasma acts as an irritant either to the vessel walls or to the vasomotor centre, producing constriction of the arterioles, and a consequent general rise of blood-pressure. The task of excreting the excess is undertaken mainly by the kidneys, and the amount of work thrown upon them is out of proportion to the physiological necessities, so that sub-oxidation and deficient excretion results leading to dyspepsia, gout and constipation. Fermentative and putrefactive processes are set up with the generation of offensive gases leading to dyspeptic troubles. These may be attended with either constipation or diarrhœa. Some of the products of putrefaction are absorbed into the system and give rise to symptoms of auto-intoxication. If fat or carbohydrate be in excess in the food, they set up acid dyspepsia with accumulation of much flatus. Fat is also deposited in the tissues and persons suffer from obesity.

Unbalanced Diet and Deficiency Diseases.—The maintenance of the body in a healthy condition depends upon a diet

consisting not only of the different proximate principles, *viz.* protein, fat and carbohydrate of sufficient calories to furnish the heat and energy, but also of inorganic salts, chiefly calcium, phosphorus, iron and iodine. A balanced diet should also contain all the vitamins and should provide more or less the same number of calories every day. It is further necessary that these must be presented in such a way as will help prompt and complete digestion and assimilation.

Deficiency in all the proximate principles of diet involves loss of weight, debility, poverty of blood, and prostration. Complete deprivation leads to rapid wasting, dryness of the mucous membranes, impaired action of the heart and respiratory system, low fever, restlessness, delirium, coma and finally death. Young subjects bear starvation badly and die very soon. Absence of fat leads to a state of malnutrition. Continued starvation produces the most disastrous effects on the human constitution, and the digestive functions become so altered and degenerated from disuse that when a sufficiency of nutriment is given the wasted organs cannot utilise it and the sufferer dies from inanition.

Within recent years we have realised that certain diseases may develop from the lack of certain peculiar food elements, although the diet may supply adequate calories. It is possible that deficiency in one essential of a diet may be compensated partly or wholly by adequacy of other constituents. Although there may be deficiency of one or more accessory food factors in the diet, it is also common to find other faults as well, *e.g.* proteins of low biological value, deficiency of mineral salts and so forth, so that it is rather difficult to assign one definite food deficiency as the cause of a disease. Unbalanced diet when continued long produces certain diseases known as deficiency diseases. They are as a rule chronic manifestations produced as the result of prolonged use of such a diet. Thus underfeeding, specially with a deficiency of proteins, produces *nutritional œdema*; *simple goitre* is believed to be due to lack of iodine in water or food, or both; *xerophthalmia* is caused by deficiency of vitamin A and *beri-beri* of vitamin B. It is probable that chronic enlargement of the lymphatic glands in children and septic foci common in man may be due to persistence of infection as the result of deficiency of vitamin A. McCarrison holds that whatever the specific function of any vitamin may be, vitamins are but links in a chain of essential substances necessary for normal metabolism, and should be considered in relation to the balance of food ingredients as a whole to organs of digestion and assimilation and to endocrinic regulation of metabolism.

Rickets.—Recent experiments indicate that rickets is a deficiency disease caused by the absence of some accessory

food factor or factors. It is now believed to be due to an unsuitable calcium-phosphorus ratio, or a deficiency of vitamin D, which is distinct from fat-soluble vitamin A. The ultraviolet rays of the sun seem to be able to compensate for a faulty calcium-phosphorus ratio. On the other hand other observers see no relation between diet and human rickets, and ascribe the disease to unfavourable environment, lack of sunlight, too limited air space, and lack of exercise leading to defective calcium metabolism so that lime is not deposited in the bones.

Scurvy.—Like beri-beri scurvy is a deficiency disease due to the long continued consumption of food lacking in vitamin C. The antiscorbutic vitamin is obtained in large quantities in oranges, lemons and fresh green vegetables, roots and tubers, and in small quantities in fresh milk and meat (*see* page 150).

Pellagra.—It is a disease of malnutrition and is classed by many observers with beri-beri and scurvy as a deficiency disease although the exact nature of the deficiency is not settled. It is found in Central Europe, Central America, Mexico and Africa, and cases have been recorded in Asia Minor, India, Straits Settlements, the Philippine Islands, Japan and Korea. Three views have been advanced to explain the cause of this disease, *viz.* (*a*) the infection theory; (*b*) the toxin theory; and (*c*) the food deficiency theory. The infection theory received very little support, and the intoxication theory of Lombroso that the disease was due to toxins produced in the maize has been revived, and Sabry in Egypt has suggested that intravenous injections of sodium thiosulphate may exert some beneficial effect by neutralising the toxin derived from ingestion of damaged maize. The food deficiency theory has however the largest number of supporters. One school holds that it is caused by a deficiency in the biological value of proteins, and may be wholly eradicated by proper feeding. The probable deficiency is that of some aromatic amino-acids possibly *tryptophane.* From observations made in the Russian and Roumanian fronts it has been shown that where there was pellagra the chief article of diet was mainly maize flour. Goldberger and his associates have shown that pellagra was caused by the deficiency of some essential food factor which in some respects had properties similar to those of vitamin B, but which was quite distinct from the factor which cured experimental polyneuritis. The antineuritic factor or vitamin B_1 is *thermolabile*, and the *thermostabile* factor which cures human pellagra has been named by Goldberger as vitamin p-p (or vitamin B_2) which is contained in yeast, and which has been shown to be of great value in the prevention and treatment of pellagra without the addition of foods with high protein value. Bliss put forward the 'view that both human and experimental pellagra in rats was due to iron deficiency, and

Guha (*British Medical Journal, July 11, 1931*) pointed out that pellagra was a complex syndrome arising from an association of various factors, deficiency of Goldberger p-p factor being an important though not the sole factor. He holds that vitamin B_2 plays an important part in iron metabolism. The deficiency of vitamin B_2 theory has been further challenged by Aykroyd who showed that this vitamin was present in larger quantity in whole maize than in over-milled rice and millet, while in the endosperms of each it was equal and in low amount, and pointed out the fact that the rice eating people suffer from beri-beri and not from pellagra. Harriette Chick has suggested that the known facts might be explained by the hypothesis that some toxic substance derived from maize may be rendered innocuous by the action of the pellagra preventive p-p factor or vitamin B_2.

The different ways in which a diet may be ill-balanced or maladjusted have been classified by McCollum as follows:— (*a*) An inadequate supply of the inorganic constituents. (*b*) Inadequate amount of protein, or the use of protein of poor quality, *i.e.* not containing all the necessary amino-acids. (*c*) A lack or deficiency in one or both of the accessories, fat-soluble A and water-soluble B. (*d*) The presence of toxic substances in certain foods.

Endemic Goitre.—The causation of endemic goitre received a good deal of attention in recent years, and the disease is now regarded by some as a deficiency disease due to lack of iodine in food and water. Two types of endemic goitre are generally seen, the classical type, *i.e.*, parenchymatous or simple hypertrophic goitre, and the diffuse colloid goitre. The former type occurs in mountainous regions and is essentially a place disease, and is found amongst agricultural populations; while the latter type occurs specially in lowlands. Both varieties may occur in the same locality From time immemorial the disease has been associated with water. Various causes have been assigned, such as (*a*) excessive richness in some chemical ingredients, *e.g.* hardness; (*b*) presence of some organic impurities, notably some pathogenic agents or their products; and (*c*) poverty of iodine. The iodine deficiency and the infection theories have received the largest number of supporters. It has been argued that goitre begins to appear when the iodine in the thyroid gland becomes deficient and that there is deficiency of iodine in the soil, water and food of goitrous regions. McCarrison, after careful experimental evidence extending over several years in India, came to the conclusion that association of goitre with a low iodine-content of the food was not invariable, nor was iodine-deficiency the essential cause in this country, inasmuch as goitre was produced in animals fed exclusively on iodine-poor food like

white flour and rice. He produced experimental goitre in men by giving them to drink suspended matter removed from grossly polluted goitre-producing water, although these men were encamped on grounds containing 15 parts of iodine per 13 million parts of soil and the water contained 1200 parts of iodine per 100 billion parts of water. On the other hand no goitre was produced in those who drank the same suspended matter which was previously boiled. The evidence put forward conclusively proved the presence of goitre-producing agent in the water and which was destroyed by boiling, although goitre was not prevented by the iodine in the water when unboiled suspended matter was given to drink. According McCarrison the causation of chronic hypertrophic goitre is closely interwoven with the composition of food (deficiency of vitamins A,B and C), with the state of the gastro-intestinal canal, with the concentration of the toxic metabolites in the system, and with the role of the thyroid gland and of iodine (alone or in collaboration with the thyroid) in the phenomena of nutrition and oxidation. Although it is possible that deficiency of iodine may have some part in the causation of goitre, the essential cause according to McCarrison is a positive toxic agent derived from the gastro-intestinal tract.

Very little is known regarding the geographical distribution, epidemiology and etiology of colloid goitre. It has been suggested that disturbance of the calcium-iodine balance in the food and possibly in the gland itself may have some relation in the pathogenesis of this disease.

CHAPTER VII

DIET IN INDIA*

THE consideration of the subject of dietary with special reference to India is a very difficult problem. A country inhabited by people of different nationalities, castes and creeds, habits and customs, physical growth and development naturally shows a divergence in the food they eat. Hindus from time immemorial have got into the habit of living purely on a vegetable diet. Although there is less prejudice in recent years against taking animal food as part of their daily diet, meat is not taken habitually by the majority of Indians. Pure vegetarians are found in many parts of India enjoying the best of health. But it should be noted that milk and its preparations, though derived from the animal kingdom, are not excluded from the diet of even the strictest vegetarian Hindu; eggs, however, are not eaten by any of these vegetarians.

NUTRITIVE VALUES

Before going into details let us analyse the nutritive value of vegetable food. Based on chemical composition alone the proteins, carbohydrates and fats of vegetable food are almost equal in nutritive value to the corresponding substances derived from the animal kingdom. But vegetable protein cannot entirely replace animal protein, some of the amino-acids essential for nutrition being lacking (*see* p. 144). It is therefore inferior in nutritive value to protein of animal food. On the other hand some German observers have shown that the nitrogen equilibrium suffers no impairment if the protein of meat and milk be replaced by a similar quantity of protein in the form of peas and beans, provided the food contains a sufficiency of all the vitamins.

As regards carbohydrates, it is enough to say that they are almost entirely derived from the vegetable kingdom, and their value as food is beyond any dispute. With regard to fat it has been proved by experience and experiments that vegetable fats are as valuable a means of nourishment as the fats of meat or milk.

It must not, however, be supposed that simply because the chemical constituents of vegetable food are equal in nutritive value to the corresponding constituents of animal food, vegetable food can replace animal food or *vice versa*.

* B. N. Ghosh, *Journal of the Royal Institute of Public Health*, London, May, 1911.

For instance, a glass of whisky is chemically the same whether it is taken raw or diluted, but the effects are markedly different. The real question to consider is that of protein absorption of a vegetarian, for carbohydrates must of necessity be derived from a vegetable source.

Standard Jail Diet

Let us now consider some standard vegetarian diet, and for this the ordinary jail diet of Bengal may be taken as a type, which consists of:—

Rice ...	... 26.65 oz.	or 755.80 grm.
Dals ...	... 6.15 oz.	or 174.41 grm.
Vegetables	... 6.15 oz.	or 174.41 grm.
Mustard oil	... 0.64 oz.	or 18.14 grm.
Condiments	... 0.26 oz.	or 7.37 grm.
Antiscorbutics	... 0.26 oz.	or 7.37 grm.
Salts ...	... 0.90 oz.	or 25.52 grm.

The value of this diet in proximate principles is as follows:—

Foodstuffs.	Rice.	Dal.	Vegetables.	Oil.	Total (in grm.)
Protein ..	51.63	39.32	2.36	...	93.31
Carbohydrate	589.55	94.72	9.06		693.33
Fat ...	6.80	4.76	1.58	17.35	30.49

The above therefore represents the average composition of the diet in use in the Bengal jails, and according to the accepted heat equivalents its caloric value is 3508, which is about 1000 calories higher than is furnished by Ranke's diet (*see* p. 173). But the total bulk of the above diet is so great that digestion and absorption are interfered with, and only a portion of the 93 grammes of protein is actually utilised by the system; in fact, the real nutritive value of the above diet is a little more than 60 to 65 grm. But the effect of adding wheat-atta, fish, or meat to the above diet, reducing at the same time the amount of rice and dal, is a sudden rise of the protein absorption, the actual protein metabolism being largely augmented.

Thus on a diet consisting of

Rice	... 18 oz.	Atta	... 4 oz.
Dal	... 5 oz.	Vegetables...	6 oz.

the average metabolism is 8.50 grm. of nitrogen daily. In fact, the protein metabolism is considerably increased with a diminution of about 50 per cent. of nitrogen residue in the stools.* The reduction of rice from 26 oz. to 18 oz. daily therefore helps not only to bring the carbohydrate element

* "Scientific Memoirs," Government of India, No. 37, 1910.

and the total caloric value of the diet within the bounds of physiological limits, but also assists in reducing fermentation in the intestines.

It was believed that Mahomedans, who are used to animal diet, are better able to absorb the protein from an animal food than Hindus, who are largely vegetarians. As the result of investigation by McCay* upon Mahomedans and Hindus placed exactly on the same diet identical results were obtained. The diet was as follows :—

Bread	8 oz.
Mutton	12 ,,
Fish	6 ,,
Potatoes	4 ,,

The value of this diet in nitrogen is 16.29 grm. According to McCay the degree of nitrogen absorption depends more upon the manner in which the protein diet is made up than upon the absorptive power of the intestinal canal.

Food and Physical Development

We are now in a position to consider the question of the relationship of food to physical development. From the researches made on the metabolism of the Bengalis and on their nutrition, it is evident "that the average native of Bengal, even the members of the well-to-do classes, exist on a metabolism of less than 4 grm. of protein per man daily on the ordinary diet of the province."* The opinion that the sociological conditions, vigour, and physical development of a race are in close relation with the amount of assimilable protein, is almost unanimous. The progress of a nation will be hampered if the citizens are ill-fed, for upon food depends not only life itself, but the power to work and to resist disease. A well balanced diet therefore has a far-reaching influence upon the development of the race, an influence which is directly seen in the physical well-being associated with an adequate supply of suitable food. The result of protein starvation with deficiency of vitamins A, B and D, especially in the early growing period of life, when in addition to the elements required for repair and formation of energy an extra quantity is required for growth, is disastrous, for this may result in imperfect growth and development, the consequences of which may be very lasting. With the rice-eating inhabitants of India there is a loss of tissue protein with an accompanying loss of vigour and strength and a comparatively low capacity for prolonged or sustained muscular work. It is therefore of vital importance to consider the particular diet that will suit the people of India. More assimilable protein and not excess of carbohydrate, is what is needed in the diet. But it does not

* McCay: Scientific Memoirs, 1910.

follow that protein from meat alone should be taken to build up the tissues of the body.

McCarrison, as the result of careful experiments on the diets of the different peoples of India, has come to the conclusion that the physical efficiency and well-being of any race is largely a matter of the food they eat. It is not only because the diet of the Sikh contains more suitable protein than that of the Bengali--although this is a matter of great importance—nor because it contains more vitamins, that the Sikh excels the Bengali in physical efficiency and well-being, but because the diet of the Sikh contains *all* those elements and complexes necessary for the maintenance of perfect nutrition. Each essential constituent of food is a member of a team on the co-ordinate action of which perfect nutrition depends. If we look to the history of the human race, we find that man has been guided in the selection of his food by the circumstances and conditions with which he has been surrounded. The physical organisation seems capable of the remarkable power of adapting itself to such food as may be procurable. Thus, in Arctic regions where no vegetables can be had man lives exclusively on meat and fat; similarly in India where fruits and nutritive vegetables abound, and are easily procured, these are consumed very largely.

There is another side of the question, namely there are degrees of health, and that while health and muscular strength can be maintained upon a purely vegetable diet, a careful consideration will show that those who live on such a diet are lacking in what is called energy. One must carefully differentiate energy from strength. The former is a property of the nervous system, the latter of the muscle. Carbohydrates derived from vegetable food supply the muscle, whereas the brain requires nitrogen which is obtained from the protein food only. Energy and strength derived from animal and vegetable food are very well explained by the following lines of Haughton. "The hunted deer will outrun the leopard in a fair and open chase, because the work supplied to its muscles by the vegetable food is capable of being given out continuously for a long period of time; but in a sudden rush at a near distance, the leopard will infallibly overtake the deer because the flesh food stores up in the blood a reserve of force capable of being given out instantaneously in the form of exceedingly rapid muscular action." One of the objections to living purely on vegetable food is that one has to consume a much larger quantity of vegetable than of animal food to obtain the necessary amount of nourishment, for, as has been shown above, a large amount of protein would pass out of the body unutilised, and the albumin of vegetable substances is often mixed up with large quantities of starch enclosed in a network of cellulose which is resistant to the action of digestive juices.

The commonest and the worst of all diets in use by Indians consists of rice, dals, vegetables and condiments. This diet is poor in protein, in certain mineral elements and in certain vitamins; and, consistent with these defects, the users have the worst physique, low power of resistance to bacterial infection and the worst health of any of the races of India. Another diet largely used by the people of the United Provinces is made up of wheat atta with dals, vegetables and condiments. It is a better diet than the above because wheat provides a better and larger amount of protein, and while it is deficient in certain respects (as in vitamin A), it is less so than the pure rice diet. Consistent with the better quality of this diet the physical efficiency and general well-being of its users are of a higher order than that of the users of a rice diet.

It is, however, when we consider the foods of Rajputs, the Sikhs and the Pathans, who supplement their diet with animal foods, especially milk and milk products, that we meet with the highest degrees of physical efficiency to be found in India. But man, whose gastro-intestinal tract is less capacious than that of the herbivora, cannot obtain from vegetable foods alone all the essentials for his energy requirements, nor for the attainment of the highest degree of physical efficiency. He can obtain a sufficiency of certain essentials, such as carbohydrates, mineral elements and vitamins from vegetable sources, but it is necessary for him to supplement his diet with a certain amount of animal food.

It is generally believed that high protein consumption ensures greater resistance to infection, and that epidemics are more common amongst ill-fed vegetarians, but Carter of Birmingham found that the incidence of tuberculosis had no relation to the protein of the diet, whereas it was clearly related to poor energy value. It is the deficiency of vitamin A that lowers the power of resistance to bacterial infection.

PHYSIOLOGICAL EFFECTS

The physiological effects of the increased bulk of vegetable food call for some consideration :

1. The stomach and bowels become somewhat distended, as evidenced by the disproportionate development of the abdomen of herbivorous animals, and also in the so-called "potato-belly" of the Irish peasants and the fat belly of the Indian vegetarians. But this increase in capacity of the abdominal organs, by which the greater bulk of a vegetable food is accomodated, is not accompanied by an increased power of digestion and absorption.

2. The operation of the stomach and intestines upon a large bulk of vegetable food necessitates increased muscular effort by these organs, which implies a large expenditure

of blood and nervous energy, and, consequently there is less of these left for other purposes.

3. The larger amount of water which is an important feature in vegetable food, is also a disadvantage, for this does not lessen the intake of water; on the other hand, it renders the tissues more or less flabby and dilutes the blood.*

It may be mentioned that increased vegetable food has less influence on those engaged in out-door work than on those engaged in sedentary pursuits. For a labourer requires a large amount of carbohydrates to perform muscular work, and the free action of the skin carries off the excess of water which such a diet contains.

Daily Diet

Admitting, therefore, the value of proteins in the diet and that the animal protein is the most assimilable of all, the question which naturally suggests itself is what should be the diet of the people of India. Is it possible to live on the same diet as Europeans do in India? Voit and Cramer pointed out that persons who have for years been accustomed to one form of diet absorb its constituents no better than those to whom such a regimen is a comparative novelty. As the result of investigation on Hindus and Mahomedans, McCay corroborates the above statement (page 167). But we find that the testimony of some experienced medical men is quite different: "It has often been said that Europeans in India should imitate the natives in their food, but this opinion is based on a misconception. The use of ages has accustomed the Hindu to the custom of taking a large quantity of rice with pulses and corn. Put a European on this diet and he could not at first digest it. The very bulk would be too much for him."† Again, Sir Joseph Fayrer makes the following observation: "It is not advisable to copy the natives in respect of diet. Neither the mode of living nor the quality nor the quantity of the aliment can be changed with impunity. The stomach of the Anglo-Indian will no more obtain from the dietary of the Hindu all that is necessary for nutrition than it could in other circumstances from the blubber that delights whilst it nourishes the Eskimo." If the above is true for Europeans, the reverse should hold good for Indians. Pawlow has shown that the pancreas pours out a secretion whose properties vary with the nature of food supplied. If the animal is fed on meat the secretion becomes rich in trypsin, and if the diet be starchy the proportion of amylopsin in the juice becomes greater.

*Hutchison's *Food and Principles of Dietetics*.
†Burney Yeo's *Food in Health and Disease*.

SUPPLEMENTING THE PROTEIN ELEMENT

We have now to consider how the deficiency of the protein element can be supplemented. There are three methods by which this can be done :—

1. By adding a moderate amount of food derived from the animal kingdom. In meat and fish we have concentrated forms of protein foods and by their use we can supplement the nitrogenous element which would otherwise be deficient in the diet. This diet is best suited for Europeans in India. In a suitable mixed dietary the proportion of animal food should not be less than 25 per cent., and according to Voit it should be 35 per cent.

2. Some vegetarians supplement the protein of their diet by taking milk or eggs. In fact, milk and its preparations are taken by most of the vegetarians in India. A liberal use of milk or curd (*dahi*) will no doubt remedy certain deficiencies of a pure vegetable diet, and there can be no physiological objection, except the difficulty of obtaining it pure, when the question of expense has also to be considered.

3. For those who do not even take milk or fish, or cannot afford to have them, the only method of increasing the total protein is by taking large quantities of such foods as are especially rich in nitrogen, as atta, pulses, etc. But the disadvantage of such a diet, necessitating consumption of a large bulk of food, has already been alluded to.

STANDARD INDIAN DIET

A diet, therefore, that will suit the average Indian and at the same time maintain the high standard of protein metabolism would be a compromise between the European and the orthodox Hindu diet. The following is a good diet for Indians provided the rice is not polished and whole-meal atta is used.

Rice	.. 8 oz.	Fish	.. 4 oz.
Atta	.. 6 „	Vegetables and fruits	.. 6 „
Dal	.. 4 „	Milk or curd (*dahi*)	.. 12 „
Oil or Ghee	.. 3 „		

The value of the above diet in proximate principles is as follows :—

	Protein.	C. H.	Fat.	Calories.
Rice 8 oz.	16	204	2	832
Atta 6 oz.	21	120	4	621
Dal 4 oz. ...	29	64	3	400
Oil or ghee 3 oz. ...	.		87	783
Fish 4 oz.	20	...	8	160
Vegetables and fruits 6 oz.	2	6	..	30
Milk 12 oz. ...	12	14	12	210
Total in grammes ...	100	408	116	3027

To the above diet may be added 8 oz. of meat once or twice a week when the food value will be increased correspondingly as follows :—

Protein, 44 and fat, 50; with an increased Calorie of 585, giving the total of protein 144, fat 166 and 3612 Calories on those days.

Those who do not take fish should supplement the above diet with an additional four ounces of milk, curd or *dahi*. In every case the diet should contain sufficient green leafy vegetables which should be eaten raw after proper washing. In addition to the above sugar or *gur* should be taken.

It should be noted that the diet of rice, wheat, lentils, etc., used by the majority of Indians is well suited to the climate and to their constitution. The defect in the orthodox Hindu diet is its poverty in the protein element. The addition of wheat atta to one of the two daily meals causes material improvement. During the hot months many Europeans take meat very sparingly. In fact, there is less craving for animal food in hot weather, and also a less capacity for digesting it, especially when it is of a fatty nature.

The following diet is recommended for Europeans in India :—

	Protein.	C. H.	Fat.	Calories.
Bread 8 oz.	24	144	. .	720
Meat 8 oz.	44	. .	50	585
Cheese 1 oz.	6	1	3	47
Eggs two	12	. .	12	156
Butter 3 oz.	. .	. .	72	648
Potatoes 6 oz.	6	36	. .	168
Fruits & Vegetable 6 oz.	1	4	. .	20
Milk 8 oz.	8	9	8	140
Rice 4 oz.	8	102	1	432
Fish 3 oz.	16	. .	3	108
Total in grms. . .	125	296	140	3004

The diet of Europeans in India should also be modified. It is not a sound practice to live on a purely European diet in India. In a suitable mixed dietary the proportion of animal food should be less than one in four. If this is exceeded, an undue strain is imposed on the eliminatory organs and the liver. A well-balanced European diet should contain a liberal amount of green vegetables, fresh raw fruits and substitution of whole-meal bread or chapaties in place of white bread, and a liberal use of good milk (McCarrison). The following are the remarks of Professor Simpson on the subject: "When the Aryans first descended into the plains of India they were meat-eaters, but the experience of the centuries evidently taught them to be vegetarians, or to be

very sparing in the amount of meat they ate, and at the same time to become total abstainers. This is an experience, the lessons of which the Europeans who go to the tropics are inclined to ignore. Accustomed to living well in their own country, in which large quantities of meat, fats and rich food, as well as wines and spirits, form an important part of their diet, they are tempted to continue, as closely as possible, a similar diet in the tropics."

As compared with the above diets the standard ration for the European and Indian soldiers given below will be of some interest :—

Indian soldiers: rice or atta, 1½ lb.; dal, 3 oz.; sugar, 1½ oz.; ghee, 2 oz.; potato, 2 oz.; salt, ½ oz.

European soldiers: Bread, 1 lb.; flour, ½ lb.; meat, 1 lb.; onions, 6 oz.; potato, 10 oz.; salt, ½ oz.; sugar, 2½ oz.; tea, $\frac{5}{7}$ oz.; vegetables, ½ lb.

Dr. Chuni Lal Bose of Calcutta has recommended the following scale of diet for students of Bengal, *viz.* rice, 5 oz.; dal, 2 oz.; fish, 6 oz.; potatoes and other vegetables, 10 oz.; atta, 10 oz.; oil or ghee, 2 oz.; sugar, 1 oz.; dahi, 4 oz. This diet yields nitrogen 300 grs., carbon 4,500 grs., and 3000 Calories of energy.

The comparative value of the European and Indian diets as recommended by the writer is as follows :—

	Protein.	C. H.	Fat.	Calories.
European (Author's)	125	296	149	3004
Indian (Author's) ...	100	408	115	3027
Ranke	100	240	100	2324
Atwater	125	400	125	3315
Voit	118	500	56	3055

The main points that have been discussed may be summarised as follows :—

1. Vegetable foods are rich in carbohydrates and vitamins, and with some exceptions, deficient in fat and nitrogenous substances.

2. Vegetables are bulky, due to richness in starch and cellulose and to the large amount of water which they contain.

3. Some that are compact in their raw state become bulky on cooking.

4. They are less easily digested and less completely absorbed than animal foods, due to bulkiness and their tendency to undergo fermentation in the intestines, with production of acid bodies which stimulate peristalsis.

5. A pure vegetarian must either live upon a diet poor in protein or consume a large bulk.

6. Meat, fish, egg, milk, *chhana* (casein), etc., may be

used to supply the deficiency of the protein element, and for healthy persons a moderate use of fish, milk, curd, or meat may be of advantage.

7. Both from a chemical and physiological point of view a purely vegetable diet (milk excluded) is apt to be deficient in protein element.

8. A well balanced diet contains sufficient raw fruits and green vegetables supplemented by such animal foods as fish, milk or any of its preparations; in fact two-thirds of the total protein may safely be taken in the vegetable form.

CHAPTER VIII

VEGETABLE FOODS

THE most prominent feature of vegetable foods is the large proportion of carbohydrates which they contain. But it must not be supposed that vegetable foods are merely carbohydrates; they contain almost all the vitamins, protein and fat; and some, especially the pulses, are rich in protein, while others, as nuts, are rich in fat. But vegetable foods as a whole, more than the animal foods, contain more representatives of the three groups of nutritive substances.

Vegetable proteins mainly belong to the class of globulins, and are dissolved in water with a little sodium chloride. Nucleo-proteins are less in vegetable substances than in animal tissues. But vegetable proteins are comparatively poorer in carbon and richer in nitrogen.

Both animal and vegetable proteins are coagulated by heat and rendered less digestible by cooking, and while cooking diminishes the digestibility of animal foods it increases the digestibility of vegetable foods. This is due to the fact that animal food contains chiefly proteins, while vegetable food contains proteins to a less extent than carbohydrates in the form of starch, which as we have seen (page 154) is rendered more easy of digestion by cooking.

Vegetable fat is the most concentrated of all the non-nitrogenous materials that are evolved in plants, and is one of the most convenient forms in which such materials can be stored. It resembles animal fat in composition and is produced by the action of fatty acids upon the basic glycerol radical.

Vegetable fat is of great importance in the economy of the human race. A necessity of existence in all cold countries, fat, in the shape of oil or butter, is largely consumed as human food. Excepting olive or such other vegetable oils, the majority of fats consumed are derived from animal sources; with the exception perhaps of *ghee* in India, the greater number of oils used in the tropics are of vegetable origin. The vegetable oils are expressed from various seeds and are used for cooking. The oils chiefly used are derived from the mustard seeds, ground nut (*Arachis hypogea*), cocoanut, soya bean, *til* or sesame.

Vegetable oils are poor in vitamin A, and most of the vegetable *ghee* or butter contain none, being destroyed by the process of hardening.

Carbohydrates of vegetable food exist chiefly in the form of starch and sugar. It is in the form of starch that carbohydrate is stored up in the plant, and this abounds in all plants, particularly the seeds of cereals and legumes, and

in potatoes and other tubers. Starch is more appropriately the surplus carbohydrate and cannot be utilised as such by the plant. It is in the form of sugar, the soluble carbohydrate, that it circulates in plants. When needed by the plant, part of this starch is converted into sugar by the ferment diastase, and circulates in the plant just in the same way that it undergoes changes in the human body. *Starch* being insoluble in water is stored up in the plant ; and is a more concentrated form of carbohydrate than sugar.

In boiling water the starch grains swell and burst and form a gelatinous solution. By cooking, these starch granules are broken up to be more easily acted upon by the digestive juices. Just as proteins, the nutritive constituents of meat are enclosed in minute tubes of connective tissues, so also starch, the chief ingredient of vegetable food, is enclosed in a network of cellulose. Cellulose is a carbohydrate but is resistant to the action of digestive juices. When old it becomes woody. It is obvious, therefore, that it must present a great obstacle to the penetration of the digestive juices.

The common forms of vegetable food may be divided into : (1) Cereals, (2) Pulses, (3) Roots and Tubers, (4) Green Vegetables, and (5) Fruits and Nuts.

1. CEREALS

Cereals belong to the tribe of grasses, and the use of the seeds is widely spread over all parts of the globe, as a valuable article of food. Of these, wheat is mainly used in Europe, maize in America, and rice, maize and millet in India. Cereals not only contain a large quantity of nutritive material condensed in a small bulk, but also a considerable proportion of mineral substances, the most important being the phosphates of calcium, magnesium, potash, a small amount of iron and silica. The different nutritive ingredients—protein, carbohydrate and fat—are represented in cereals ; they are, however, rich in nitrogenous substances, starch and cellulose, but poor in fat.

The seeds are usually ground into meal when used as food. This process, besides reducing the hard seeds into powder, removes the outer indigestible coat which is composed of woody cellulose.

Of the different cereals, maize is relatively rich in fat and slightly deficient in salts ; rice is very rich in starch but poor in nitrogenous substances, fat and mineral matter ; oats, on the other hand, are especially rich in fat and protein, and rank as the most nutritive of all cereals. Millets are inferior to wheat in the proportion of proteins, but superior to it in fat. But the preponderance of carbohydrates in all cereals precludes these being used alone ; in fact they

should be eaten with other foods rich in fat and protein. As a rule they are very easily absorbed and are not only compact but possess high nutritive value, which places them in the front rank of all human foods.

Mellanby (*British Medical Journal*, April 12, 1930) has pointed out that cereals interfere with the deposition of calcifying salts in bones and teeth. Of these oatmeal is the worst offender, although oats are far richer in calcium and phosphorus than white flour which interferes least with the calcifying process. Intermediate between these are maize, rye, barley and rice. In other words, a greater deficiency of calcium and phosphorus in the body can be brought about by diets which actually contain more of these substances. These effects are antagonised by the presence of vitamin D, whether given in the form of diet or supplied to the body as the result of activation of ergosterol in the skin by sunlight.

McCarrison experimenting on rats has pointed out the stone-producing potency of different cereals, *viz.* wheat, millet, rice and *cambu* or *bajri*, which form the staple food of India. He has shown that a diet containing 9 parts of *cambu* did not cause stone within 515 days; whereas one containing the same quantity of whole wheat flour (*atta*) caused stone in 31.7 p.c. of the rats fed upon it within 351 days. Millet and rice have approximately the same degree of potency, but less than oatmeal and still less than whole wheat flour. The presence of fat-soluble vitamins, such as are contained in whole milk, prevents the stone-producing effects of the cereals.

The composition of some of the common forms of cereals is shown in the following table :—

	Gross protein.	Available protein.	Avl. Fat.	Carbo-Hydrate.	Mineral matter.	Calories per ounce.
Oatmeal ..	15.0	12.0	7.0	64	2.0	108
Barley ...	10.0	8.0	2.2	69	2.4	97
Millet ...	8.2	6.6	4.2	68	1.7	98
Maize ...	8.4	6.7	4.7	72	1.3	101
Rice ..	7.7	6.5	0.4	76	0.4	94
Wheat ...	12.0	9.6	1.7	67.5	1.2	98

Wheat

This is the most important of all the farinaceous seeds, and is extensively used all over the world. If a grain of wheat be cut and examined under the microscope the following may be distinguished :—

1. The germ or embyro—forming about $1\frac{1}{2}$ per cent. of the entire grain.

2. The kernel or endosperm—forming about 85 per cent. of the grain, and consisting of two large masses of nutritive material.

3. The bran or the outer covering; this is of darker colour than the interior and composed mainly of cellulose and mineral matters, forming about 13.5 per cent. of the grain.

A grain of wheat, free from the husk, when ground between millstones and sifted is separable into *bran* and *flour*. Flour is divided into three portions: *sooji* is the coarse grain derived from the outer coat of wheat and contains a high proportion of proteins and vitamin B; *atta* is the next layer of finer grain; and the fine white flour or *maida* is produced from the innermost layer. Bran, however, is not devoid of nutriment, and is composed of nitrogenous matter 15 p. c. and fat 3·5 p. c. The germ is especially rich in protein and fat, the endosperm in starch, and the bran in mineral matter and cellulose. Whole meal is made from entire grain.

Flour when mixed with water forms a tenacious mass known as *dough*, from which macaroni, vermicelli, etc., are prepared. If on the other hand this dough be rubbed and washed with water on a fine sieve or muslin, there remains ultimately a white sticky mass behind, while the washed fluid contains starch, which on being allowed to rest falls to the bottom. The sticky mass is called "gluten" and is the chief nitrogenous element of flour. The presence of gluten in wheat helps in the formation of bread, as it has sufficient coherence to remain spongy.

Flours are of different qualities according to their coarseness, the coarsest kind being known as *pollard* or *bran flour*. Wheat atta used for the preparation of different articles of food should always be fresh. Good flour should be white in colour without any smell or odour, silky to the touch and not gritty. Fine white flour as prepared in mills is apt to cause constipation, and is of less nutritive value and contains less mineral salts. Flour should be stored in bags and kept on wooden platforms.

"Whole-meal" with all the constituents of the grain is more nutritive, but the bran-cells are hard and indigestible, and often irritate the intestinal canal. It is, however, of great value to people suffering from chronic constipation. A "decorticated whole wheat meal" is also prepared where the outer or more indigestible layer of bran is separated from the highly nutritive inner tunic.

Preparations from Wheat Atta and Flour

Bread.—This is the chief product of wheat atta, and is made by converting flour into a firm and porous substance, ready for easy mastication, and while containing some water, is not moist or sticky.

Bread is prepared by first forming a dough and then imparting the necessary property of porosity, which is essential for easy digestion, either by generating within its substance or by forming without, carbonic acid gas. Generation of gas within the dough is effected by either of the following methods producing different varieties of bread.

1. *Fermented Bread.*—When yeast is added to the dough fermentation ensues, CO_2 gas is generated and is entangled within the tenacious material which swells up into a spongy mass, being rendered porous and light. If at this stage it is placed in an oven and baked, fermentation becomes arrested and the whole mass hardens up into bread. The ferment generally used is yeast. When yeast or any other leaven is thus used the bread is known as *leavened bread.*

2. *Unfermented Bread.*—Under this head is included such bread as is vesiculated by the use of baking powders for the evolution of CO_2 gas. Although it serves the purpose very well, it appears that the less chemicals are used for culinary purposes, the better.

3. *Aerated Bread.*—When CO_2 instead of being generated by fermentation within the dough is separately prepared and incorporated with flour and water, aerated bread is produced. In this process no chemicals are used, and as it entails no handling, it is quite a clean and sanitary process. The bread keeps sweet and good for a longer time than fermented bread.

A good bread contains about two-third of its volume of gas, and of the solid part about 45 per cent. consists of water.

Baking increases the digestibility of bread, the nitrogenous constituents are changed, and the starch granules are ruptured. Well-baked bread should have a yellowish brown crust, should be uniform in texture, and be permeated by minute cavities, but without eyes or large air-cells. The colour of the crumb, except in whole-meal bread, should be white and the bread should not taste acid or sour. With some stomachs even the best fermented bread disagrees, and for them the aerated bread may be recommended.

Newly made bread is soft and tenacious, stale bread crumbles readily into separate particles. Being more palatable and sweet, new bread, however, is generally preferred to stale bread; but it is less digestible as it gets clogged together during mastication, and when swallowed reaches the stomach in non-porous lumps, and consequently is not so easily acted upon by the saliva and the gastric juice. This is obviated by toasting, which renders the bread more friable and allows it to be more readily acted upon by the digestive juices. Toast should be thin and crisp and eaten soon after it is made. Weight for weight, bread is one of the most nutritious of all our foods, and the fact that it is always eaten with butter, makes up for the deficiency of fat.

Certain substances are often used as adulterants in the

preparation of bread, the chief being alum. It is used to make the bread look whiter, but it also helps in the formation of a good dough when the flour used is either old or produced from badly ripened grain. The presence of alum is detected by adding to the crumb a mixture of logwood and ammonium carbonate solution, when a violet or blue tint is produced. But this test is unreliable when the bread is sour.

Biscuits are made from flour and water. They contain little fat and very little or no water. Milk, sugar, butter, eggs and flavouring substances are sometimes added. They are more nutritious than bread.

Rusks are made like bread with milk, butter and sugar in addition. They are cut into pieces, roasted and thoroughly dried. They are like toast.

Macaroni and *vermicelli* are preparations of wheat. They are rich in gluten but poor in fat, quite nutritious and easily assimilated. They are usually prepared with milk or cheese. *Force* is whole wheat malted and cooked with steam. It is sold in the form of crisp flakes.

Shredded wheat is easily digested and valuable for invalids. A preparation from wheat germ containing a large amount of vitamin B is sold under the name of *Bemax*.

Chapaties.—These are non-aerated hand-made unleavened breads prepared by first making the dough and then spreading it over a smooth surface. They are of a circular shape and of thickness varying from that of a thick paper up to one-sixth of an inch. Chapaties are fried dry on a frying pan and then baked over fire. Prepared from good flour they are light and white, and when properly baked they are blown out with air in the centre. During this process the starch granules swell and are made ready for easy digestion. As a rule they are eaten smeared with *ghee*, thus making up for the deficiency in fat. Chapaties contain 6.7 p.c. gross protein ; 5.0 p. c. available protein ; 1.0 p. c. available fat ; 47.5 p. c. available carbohydrate ; 1.2 p. c. mineral matter ; and yield for every ounce 64 calories. As compared to this, bread yields gross protein 7.5 ; available protein 6.0 ; available fat 0.7 ; available carbohydrate 50.0 ; mineral matter 1.0.

Sooji or *semolina* is the coarse part of wheat grain which has been sifted after grinding. It is rich in vitamin B. It may be cooked with milk and sugar, or may be used as *haloodh* by frying first with a little *ghee* or butter and then adding sugar, milk and water.

RICE

This is most widely cultivated in the East and forms the staple food of the Indians. Properly, rice is paddy deprived of the husk. Different varieties of rice are to be had in the market. They are chiefly as follows :—

(*a*) *Atap rice.*—In this variety the paddy is first soaked

in cold water and then dried in the sun. Finally it is husked either by machinery or by *Dhenki*.

(*b*) *Balam rice*.—Here the paddy is put in boiled water and kept for about 8 hours, it is then dried in the sun and husked by machinery. This rice is extensively used in Bengal.

(*c*) *Country rice* is prepared by soaking the paddy in water for 30 to 40 hours, and then transferring it into covered jars or cylinders, where it is steamed for 5 to 10 minutes. It is finally removed and dried in the sun. This parboiled rice is then roughly husked, but a large amount of pericarp still remains.

(*d*) *Rangoon rice*, or the so-called white rice is prepared from the unhusked paddy which is milled by machinery, the husk with the pericarp and the outer layer of the grains being subsequently removed; consequently it is of smaller size than country rice.

(*e*) *Home-made rice* is made by soaking the paddy in cold water, or steeped or boiled and then sun dried. Subsequently it is husked in a *dhenki* and not polished.

Of all the cereal grains rice is poorest in protein, fat, mineral salts and vitamins. Parboiled or unboiled rice provides just enough vitamin for the needs of the body, but when polished rice is used, most of the vitamins contained in the whole rice grain are removed with the outer layer, and therefore its exclusive use causes *beri-beri*. Rice does not contain vitamins A, C and D. Parboiling renders the rice grains tough, but portions of the pericarp still remain even after husking.

Its chief constituent is starch, and this exists in an extremely digestible form. About $2\frac{1}{2}$ ozs. cooked by boiling require $3\frac{1}{2}$ hours for disposal by the stomach. But it is not the function of the stomach to digest carbohydrate; it only performs the mechanical part and prepares it and sends it on to the intestines for final disposal. Rice is very completely absorbed in the intestines. Being insipid and only rich in starch, it is eaten with condiments and other foods rich in nitrogenous substances and fat, as pulses, fish, *ghee*, etc., to supply the deficiency of protein and fat.

COMPOSITION OF RICE*

	Unpolished	Parboiled	Polished	Rice bran
Vitamin B ...	+	+	0	+ + +
Protein ...	9%	7.68%	6. %	Higher
Fats ...	1.65%	2 to 2.5%	0.25 to 0.5%	22.24%
Phosphorus	0.54%	0.58%	0.26 to 0.38%	3.2%
Protective outer coat	Present	Present	Absent	

*After Greig, Fraser and Stanton.

Good rice should be entire, clean and well-husked, and non-fermenting, nor be mixed with any gravel or earth. It should preferably belong to the last harvest but one before, as new rice is apt to cause indigestion and diarrhœa. Rice which has been sown on swampy grounds and which has not been transplanted, and which comes to maturity at the close of the rainy season, frequently gives rise to gastro-intestinal troubles.

Rice should be stored in dry and well-ventilated rooms having impervious floors. When kept in hot and damp places, it ferments and develops a rice bacillus which invades the rice grain and acts on the carbohydrate and protein with production of toxins. This was suggested by Acton to be a possible cause of *epidemic dropsy*. When the rice becomes so "diseased" it can be detected by the appearance of a white opaque spot especially when the rice is put in a shallow vessel of water. Rice can be preserved by occasional exposure to the sun and by mixing lime with it. Active fermentation may be detected by putting the hand inside the bag of rice, when it will feel warm.

Rice when under-kept boils thick in the grain and is so gummy that the grains stick together, but when of good quality and condition the grains elongate remarkably by boiling ; they do not stick together, and they have a pleasant mealiness in the mouth.

Rice is not infrequently tampered with by traders, and old and new rice, or rice of different qualities are often mixed together, and chalk powder and lime are usually added to give it an uniform appearance.

Cooking of Rice.—Rice should be lightly washed in cold water before cooking. Boiling is the common method of cooking, when the rice grains swell and become soft. These are then strained and the water thrown away. This causes loss of vitamin B which is soluble in water. New rice can be cooked in about half an hour, while old rice takes almost double the time and keeps good for more than twenty-four hours after cooking. By the process of boiling some of the proteins and mineral salts are also lost. The more economical method of cooking rice is by steaming as then the protein and salts are not dissolved out.

Khichri.—In this process rice and *dal* are boiled together to a thick consistency with the addition of *ghee* and condiments. In the preparation of khichri the water is not rejected. This is not only highly nutritious but palatable and appetising.

Barley (*Job*).—This is very nutritious and is characterised by its richness in mineral matter. It is rich in nitrogenous matter, which exists in the form of casein and albumin, but the amount of gluten present is very small, and consequently barley meal is not so well suited for making bread. The

grains deprived of husk form *Scotch* or *Pot Barley*, but when all the integuments are removed and the grains are rounded and polished, they form *Pearl Barley*, and when ground to powder they are sold as so-called *Patent Barley*. It is chiefly in the form of pearl or patent barley that it is used as human food.

Malt is barley in an incipient stage of germination.

Maize or **Indian Corn** (*Makkai* or *Bhutta*).—This ground to powder forms part of the diet in some parts of India and in certain Indian jails and is as nutritious as wheat and is richer in fats than all other cereals except oats. It contains, 9.55 per cent. of protein, 66.20 per cent. of carbohydrate, 2.30 per cent. of fat, and 11.50 per cent. of water. It is deficient in gluten and does not form bread, but when mixed with milk, eggs, and other flours, forms wholesome and nutritious puddings and cakes. As it contains a large amount of fatty or oily matter it is used for fattening animals. An exclusive diet of maize protein, owing to its low biological value has been suggested as a possible cause of *pellagra*. (*See* p. 162).

Corn flour is maize flour that has been deprived of its peculiar flavour by a weak solution of soda.

Millet (*Joar*).—This forms an important food grain in many parts of the tropics, specially Africa, India, the West Indies and China. The seeds are ground and generally eaten in the form of porridge or cakes. The nutritive value is midway between wheat and rice.

Oats.—These form a highly nutritious food, and though rich in nitrogenous principle they are not considered equal in nutritive value to wheat flour. Oats are deficient in vitamins A and D and should be eaten with plenty of milk. It is also deficient in gluten, and therefore cannot be vesiculated and made into light bread. They are not so easily digested by those unaccustomed to their use. As porridge, oatmeal is very widely used by Europeans, while in the form of gruel it makes a nutritious and agreeable beverage. With some, oatmeal gives rise to a certain amount of heating effect, said to be due not so much to the presence of nitrogenous substances as to a special substance to which the name "avenin" is given.

II. PULSES

Pulses belong mostly to the leguminous order, and are richer in nitrogenous substances than any other vegetable food. This is due to the presence of vegetable protein, commonly called legumin or vegetable casein. Pulses are used in India chiefly in the form of *dals*, of which there are many varieties, *viz. moong*, *matar*, *arhar*, etc. Owing to their richness in protein, pulses are sometimes called "Poor man's

beef"; indeed for the large proportion of protein they contain pulses are used in conjunction with other foodstuffs rich in starch, *e.g.* rice. The nitrogenous ratio in pulses varies from 1 to 2 or 4. They also contain salts of potash and lime, and sulphur. As compared with cereals, these are less easily digested, and may produce a feeling of heaviness, and not infrequently give rise to much flatus.

In the dried condition pulses have no antiscorbutic properties. If however the dried seeds are soaked in water and allowed to germinate for a day or two they redevelop the antiscorbutic vitamin. They contain very little vitamin A but are rich in vitamin B. Most pulses are taken after cooking, although the green ones may be eaten raw. Lentils are rich in vitamin B and contain a large amount of nitrogenous substances and are rich in iron and phosphate of lime, and have the advantage over peas in not containing sulphur, and thus not giving rise to the objectionable hydrogen sulphide in the intestines. *Khesari dal* (*Lathyrus sativus*) gives rise to a train of symptoms when eaten for a long time, known as *lathyriasis*. The symptoms are spastic paralysis of the lower limbs and muscles of the thigh with increased knee jerks. The disease is very common amongst the poor, who live chiefly on powdered khesari dal. Howard, Simonson and Anderson have shown that the paralytic symptoms were due not to *khesari dal* but to the presence of the grains of *akti* or *akri* (*Vicia sativa*). These results have subsequently been corroborated by Acton and Chopra.

The composition of common forms of pulses is given below :—

	Protein.	C.Hydrate.	Fat.	Water.	Mineral matter.
Peas (green) ..	4.0	16.5	0.5	78.1	0.9
,, (dry) ..	21.0	61.4	1.8	13.0	2.60
Beans (dry) ..	25.5	56.4	1.7	13.1	3.3
Lentils ..	23.2	60.4	2.0	11.7	2.7
Kalai	22.58	58.02	1.10	10.87	3.61
Moong ..	23.62	53.45	2.69	10.87	3.57
Gram	19.94	51.13	4.31	10.07	3.72
Arhar	21.67	54.27	3.33	10.08	5.50
Mussur ..	25.47	55.03	3.00	10.23	3.33
Soya bean ..	32.9	33.1	18.1	11.0	4.9

Pulses should be well washed and husked before cooking. In the absence of animal food they are usually taken with rice, and being poor in fat they may with advantage be used with other fatty foods, or cooked with *ghee* or oil. They are rich in *purin* bodies, and should therefore be avoided by persons with a gouty diathesis.

When used as a source of antiscorbutic vitamin, the pulses should be entire and not husked or slit, otherwise they will

die and germination will not take place. The peas or lentils should first be soaked in water for 24 hours, when they absorb 100 p.c. of water and the process of germination commences, and the antiscorbutic vitamin begins to appear. If however the germination is continued for 24 to 48 hours the amount of vitamin is considerably increased. This is done by pouring off the excess of water and allowing the seeds to remain damp with access of air. These germinated pulses may then be cooked. Boiling should not be prolonged beyond the time required for rendering them soft and palatable, having regard to the sensitiveness of the antiscorbutic vitamin to high temperature.

III. ROOTS AND TUBERS

These may be regarded as reserves of nutriment for the use of the plant itself, existing chiefly in the form of starch; protein and fat being practically absent. Tubers are largely used as food, but are much inferior to either cereals or pulses in nutritive value, containing as they do a relatively large amount of starch and very little protein. Of the small amount of nitrogenous material a very small part exists in the form of protein. These are, therefore, not suited to form the main part of any diet. They are rich in mineral matters, chiefly salts of potash, which give them a greater value as an article of diet. They contain less vitamin B than the cereals and very little vitamin A except those that contain a pigment, such as carrots.

Digestibility of root tubers depends largely upon the amount of cellulose, but, as a rule, they are very indifferently absorbed and are prone to derange the stomach and intestines, if consumed in large quantities.

Composition of some of the common forms of roots and tubers :—

	Water.	Protein.	Carbo-Hydrate	Fat.	Ash.	Extractives.
Potatoes ..	76.7	1.2	19.7	0.1	0.9	1.4
Carrots ..	85.7	0.5	10.1	0.3	0.9	1.0
„ (cooked) ..	93.4	0.53	4.47	0.17	0.14	..
Turnips ..	90.3	0.9	6.8	0.15	0.8	1.1
„ (cooked) ..	97.25	0.32	1.67	0.06	0.32	..
Radish ..	90.8	1.4	4.6	0.1	0.7	..
Beetroot ..	83.9	0.5	14.0	0.1	0.9	1.0
Onions ..	89.1	1.6	8.3	0.3	0.6	..
Sweet Potatoes	72.9	1.6	24.3	0.5	0.7	..

Potatoes

The potato is universally used as a wholesome, palatable, and popular article of food of much nutritive value.

The potato is a valuable antiscorbutic, due chiefly to the

presence of vitamin C. Valuable and wholesome as the potato is, it is nevertheless unsuited for weak stomachs owing to the presence of large amount of starch. The digestibility of potatoes depends also on the manner in which they are cooked.

During boiling the albuminous juices are coagulated, the starch granules swell up by absorbing water, the cells in which they are contained break down, and the potato assumes a mealy or floury appearance. When mealy, the potato is easily digested, and new potatoes being less mealy are not so easily digested. Dry heat, as baking, converts the starch into a soluble form and finally into dextrose.

Steaming is better than boiling, but the skin should not in either case be previously removed. The antiscorbutic vitamin is destroyed by prolonged heating. Potatoes boiled in their jackets are digested one hour earlier than when boiled without the skin. About 46 p.c. of total nitrogen together with the mineral salts are lost when potatoes are first peeled and then boiled.

Sweet Potato.—This may be used in place of the ordinary potato. It is rich in starch (16 per cent.) and sugar (10 per cent.). When boiled it becomes very soft and forms a wholesome and useful food.

Arrowroot.—This is a preparation from the tuber of *Maranta arundinacea*, and contains about 82½ per cent. of pure starch. It forms a pure and simple starchy food of a bland unirritating character, valuable for invalids.

Tapioca and **Sago.**—Sago is obtained from the pith of sago palm. The starch grains are large, irregular, with ill-defined concentric lines. Tapioca is also pure starch obtained from the tubers of *Manihot utilissima*.

Sago, arrowroot and tapioca are all agreeable and easily digestible forms of pure starchy food, used chiefly for invalid cookery. They are also used in the preparation of pudding, etc. Alone, they have a very limited nutritive value, but may with advantage be added to either milk or soup, which are rich in proteins. They rank amongst the most completely absorbable of all foods.

Carrots, beetroot, radish, etc., are all roots of a succulent character, and are used as fresh vegetables. Beetroot is used mostly in salads and is often boiled.

Examination of Starch.

Place a drop of water on a clean glass slide and add a portion of the starch powder and mix. Put on a cover glass and examine under the microscope for—(1) shape, (2) size, and (3) presence or absence of hilum and striations.

The starch granules of potato and arrowroot are larger and oval with well-marked concentric rings or striæ and a distinct hilum, which in potatoes is at the smaller end.

The outline of the starch granules of sago and tapioca is semi-faceted with a hilum and ill-defined rings.

IV. GEEEN VEGETABLES

These have a very low nutritive value, and are used not so much for their nutritive principles as on account of the important mineral elements—calcium, sodium and chlorine—which they contain. They form salts which act as "buffers" and maintain the proper alkalinity of the blood by balancing the acid producing tendencies of meat and cereal grains. They contain vitamins A, B and C; and whenever possible they should be eaten raw as salad. Some give an agreeable flavour to the food and help digestion, and are useful as condiments. Cabbages and onions are about equally useful for the prevention of scurvy; but desiccated vegetables are almost useless for the prevention of experimental scurvy even when they are dried at low temperatures (30° to 37° C).

Green vegetables form an agreeable diversity in our food and give relish to other foods. They consist of leaves, buds, young shoots, leaf stalks, and often the entire plant. They contain a large amount of water (about 90 per cent.), and the nitrogenous material is very small (from 1 to 4 per cent.), and of this again about half only consists of protein. The deficiency of fat is often made up by cooking them in oil or *ghee*, and thus prepared they act as valuable vehicles for carrying fat into the system. Green vegetables are rich in cellulose which offers a resistance to the action of digestive juices, but the indigestible residue in the intestines acts as a "ballast" and stimulates the intestinal action; consequently they are of great value in cases of chronic constipation. Vegetables should have the stalks and midribs removed before being prepared for food, and the cooking should be thoroughly performed to separate the fibres. It should be noted that the real nutritive value of fresh vegetables, which is very low, becomes still less by cooking, and a large part of the remnant which reaches the intestines escapes absorption.

The following is a list of some of the commonly used vegetables :—

	Water.	Protein.	Fat.	C. H.	Mineral matter.
Cabbage ...	89.6	1.8	0.4	6.9	1.3
Cauliflower ...	90.7	2.2	0.4	5.9	0.8
Tomatoes ...	94.3	0.9	0.4	3.9	0.5
Celery	94.5	1.1	0.4	3.3	1.0
Watercress ...	93.1	0.7	0.5	3.7	1.3
Cucumber	95.4	0.8	0.2	3.1	0.5
Asparagus ...	94.0	1.8	0.2	3.3	0.7
Lady's finger ...	90.4	1.96	1.4	5.72	0.8
Brinjals ...	93.98	0.89	0.94	3.48	0.26
Red gourd ...	93.40	0.90	1.0	3.96	0.7

From the above it is evident that most vegetables contain a very small proportion of carbohydrate, and so they may be used by persons suffering from diabetes. Asparagus has a diuretic effect, and imparts a peculiar odour to the urine due to a volatile sulphur compound produced from it in the intestine (Hutchison). Onions, garlic, and many of the lily tribe are used chiefly as condiments for flavouring food. The volatile oil present is excreted with the various excretions, and imparts its characteristic odour to the breath, urine, etc.

Cauliflower is more easily digested than any other form of vegetable and may be used by dyspeptics. Cucumber is very indigestible, but its agreeable flavour and cooling properties have given it a great popularity. When young it is often eaten raw with salt, or as salad with vinegar, lemon juice, salt and pepper.

V. FRUITS AND NUTS

From the nutritive point of view, fruits are divided by Hutchison into "Food Fruits" and "Flavour Fruits." The latter are used chiefly for the sake of sweetness and flavour. Like fresh vegetables fruits are used because of the important mineral salts they contain. These exist chiefly in the form of salts of potash combined with vegetable acids. The nutritive value of fruits depends on the presence of a carbohydrate, which exists in the form of sugar commonly known as *lævulose* or fruit sugar.

The difference in all fruits as regards the digestibility depends on the nature of the fruit and the degree of ripeness. Certain chemical changes take place during the process of ripening. As the process begins, the fruits cease to grow, absorb carbon and give off oxygen, acids and astringent substances become less, and the starch is converted into sugar. The presence of an excess of acid in the unripe condition often irritates the bowels and may set up diarrhœa and colic.

Fruits which afford the most nutriment are the banana, date, fig, grape, mango, etc. This is due to the large proportion of sugar which they contain. The antiscorbutic property is possessed by certain fruits which are rich in vitamin C and salts of potash, lime and magnesia, *e.g.*, tomato, apple, lemon and orange. Fruit eating lessens the acidity of the urine or even may render it alkaline, owing to decomposition of various alkaline salts in the blood or tissues which are converted into alkaline carbonates and excreted as such.

Grapes are of great value and their use is directed to various purposes. The juice of ripe grapes contains grape sugar, bitartrate of potash, tartrate of lime, malic acid and water, but the amount varies with different varieties. Grapes are largely used as food, and are among the most

agreeable, wholesome, and nutritious of all fruits. Being refreshing and cooling they may be taken by invalids, but the skin and the seeds should always be thrown away, for they are apt to set up irritation of the bowels.

Dried grapes are called *raisins*, and contain more sugar and less acid and are less digestible. With milk they are often taken as gentle laxatives.

The *plantain* or *banana* belongs to the class of *food fruits.* These are most extensively cultivated in India. Plantains, both green and ripe, are largely eaten in India. The ripe plantain forms an agreeable and delicious fruit, and is often used as dessert. It contains a relatively high percentage of nitrogen, nearly 5 parts per hundred of the entire fruit, or one-fifth of the total solids. In the unripe state, when cooked with other vegetables, it is used as a nutritive article of food. Dried and ground to powder it constitutes what is called *plantain meal* or *banana flour.* This is used as a nutritive food especially suited for invalids. It contains proteins 4.0 per cent., fat 0.5 per cent., carbohydrate 80.0 per cent., mineral matter 2.5 per cent., and water 13.0 per cent. The finest banana flour, called "*bananose*," at the end of one and a half hour of pancreatic digestion develops twice as much sugar as the same quantity of oatmeal. Made into a thin gruel with water or milk it constitutes a highly nutritious article of diet.

"Bael," either fresh or in the form of sherbet, preserves or dietetic bael powder, is very useful in dysentery and forms a cooling and agreeable drink in hot weather. Ripe bael is a mild laxative.

The mango is one of the most highly prized of all fruits. It is palatable and nutritive. When unripe, it is used to make pickles, tarts and preserves, and sweetened with sugar it is made into "chutney." When ripe it is wholesome and agreeable, and is extensively used in India. Mangoes cause looseness of the bowels and should not be eaten when there is diarrhœa. Dried mango slices are known by the name of *Amchur*, and are said to be of use in scurvy.

Oranges are an exceedingly useful article of diet especially for invalids. The fresh juice allays thirst, and is well-borne in cases with much gastric irritation. Orange juice is a mild laxative for infants, and is the best remedy for infantile scurvy.

Pineapples are very common in India. They are very wholesome, and the juice of the ripe fruits contains a ferment capable of digesting proteins. Three ounces of the juice will dissolve 10 to 15 grs. of dried albumin in four hours.

In addition to the above, melons, cucumbers, apples, apricots, etc., are all used and form delicate fruits for the table.

Nuts differ from the above fruits in that they possess

higher nutritive value, being rich in proteins and fats, but are not so easily digested, because they contain much cellulose. In fact the real nutritive value of nuts is so great that they can very well replace meat. They are rich in vitamin B, contain very little vitamin A and no vitamin C.

Water chestnut (*Paniphal*) grows extensively in India on the surface of lakes, tanks, ponds, etc., and forms a staple food in Kashmere. The fruits are nutritive and cooling, and are eaten fresh. The dried fruit powdered is used as an invalid's food when cooked with milk. The dried powder contains protein 8.6 p.c. and carbohydrate 74.7 p.c.

	Gross Protein.	Available Protein.	Av. Fat.	Available C. Hydrate	Mineral Salts.	Calories Per oz.
Apples	0.3	0.2	0.3	10.5	0.3	13
Banana	0.8	0.6	0.42	14.2	0.7	19.2
Cucumber	0.8	0.6	0.2	3.0	0.5	4.8
Figs ...	1.4	1.1	..	17.0	0.6	22
Grapes ...	1.0	0.8	1.0	14.4	0.5	21
Apricots	1.0	0.8	0.5	12.0	0.4	18
Water melons	0.2	0.15	0.1	2.7	0.2	3.8

Cocoanuts, walnuts, almonds, etc., are very widely eaten in India. Nuts contain less carbohydrate, and are better suited for diabetics. Cocoanut water is cooling and refrigerant, and is a very useful drink during fatigue and thirst. The milk obtained from the ripe kernel by scraping and expression is rich in fat and protein. The kernel is a valuable food and is utilised in the preparation of different kinds of Indian delicacies.

Fruits are laxatives and valuable antiscorbutics due to the presence of antiscorbutic vitamin. Oranges, grapes, lemons, papaya, etc., are valuable in this respect. Papaya also helps the digestion of proteins, for which purpose green papaya is often used.

Fresh fruit juices appear to be among the most valuable of the antiscorbutic materials. When they are preserved their value as such is doubtful. Thus it was found that lime juice issued in Mesopotamia up to the end of 1916, during the war, had no antiscorbutic value, which arrived there after a long journey overseas and was probably over six months or more old when issued. It appears that the antiscorbutic vitamin gradually disappears on keeping.

Sugar

Sugar is an important article of diet and is obtained from the sugar-cane, beetroot, maple tree, date palm, etc. It

contains about 94 per cent. of saccharose and about 2 per cent. of water, and one gramme yields 4.1 calories of energy. Good sugar should be of a white colour, crystalline, soluble in water, and not moist to the touch. Unpurified sugars contain nitrogenous matters which on decomposition ferment. It is used as a sweetening agent and enters largely in the preparation of delicacies, syrups, etc.

Honey

Honey is the most familiar form of invert sugar and consists of the saccharine substance collected by bees from the nectaries of flowers and deposited in the cells of the honeycomb. Honey differs from ordinary sugar in containing more dextrose and lævulose than saccharose. The flavour is due to the presence of volatile substances in the flowers. It is largely adulterated with glucose, starch and cane sugar, and imitated by adding a piece of genuine honeycomb to a jar of glucose syrup. Under the microscope pollen grains will always be found present in genuine honey.

CHAPTER IX

ANIMAL FOODS

ANIMAL foods include meat, poultry, game and offal, gelatin and other foods prepared from it, fish, eggs, and milk and its preparations.

Meat consists of muscle fibres held together by connective tissue. The fibres contain muscle plasma or muscle juice, and this is made up of water holding in solution nitrogenous substances, salts and extractives. The salts are chiefly chloride and phosphate of potash. About 15 per cent. of ordinary butcher's meat is inedible, being made up of cartilage, tendon, etc.

The **proteins** of meat are myosin, muscle albumin, and hæmoglobin. *Rigor mortis* is due to the clotting of myosin, which makes the meat tough. But acids soon develop and soften the myosin, which make the meat more tender and give it a better flavour. Meat should therefore be eaten after *rigor mortis* has passed away.

The *connective tissue* of meat yields gelatin on boiling; and this gelatinisation is the result of conversion of collagen. The acids which are developed improve the flavour of the meat.

Connective tissues are more abundant in old animals than in young ones, consequently the meat of old animals is tough and requires more cooking. The amount of hæmoglobin varies in different animals. As it contains iron it is of great value in supplying that element. The important mineral matters are phosphorus and potash.

Fat is often imbedded in the connective tissues, but the amount varies in different animals. Pork and highly fatted beef and mutton contain an excess of fat. Fat is also found in swimming birds who require a large store to lighten the body and as a source of heat. A large amount of fat hinders digestion and absorption of meat possibly by forming a coating around the fibres thus interfering with their solution by the digestive juices. But the fatter the meat the poorer it is in water; in other words, fat replaces water but not the proteins.

Extractives are substances contained in solution in the meat juice. The real chemical composition of the extractives is not well understood. They have none of the nutritive value of meat, but are of use in giving the peculiar flavour and taste. Thus when meat is boiled for a prolonged period the flavour disappears and the meat becomes insipid by the removal of these extractives.

The percentage composition of the important animal foods used in the tropics is given below :—

	Protein.	Fat.	Carbohydrate.	Salt.	Water.
Beef (average)	20.96	5.41	...	1.14	72.03
Mutton ...	17.11	5.77	...	1.33	75.99
Fowl (lean)	19.72	1.42	...	1.37	76.22
Fish ...	16.0	5.0	..	1.0	78.0
Milk (cow)...	4.20	3.70	4.50	0.7	86.0
Cheese (Dutch)	28.21	27.83	2.50	4.86	36.60
Eggs ...	12.55	12.11	0.53	1.12	73.47
Butter (fresh)	2.00	85.00	...	1.00	12.95

Inspection of Animals

Animals must be kept under observation in a stock yard or cattle mart for at least 24 hours, preferably longer, before being slaughtered. During this period they must be fed and watered. They should not be too old nor too young. The composition, flavour, digestibility, etc., of meat differs with the species, age, sex, and part of the body. A good ox should weigh between 600 and 1200 lbs. and should be from 2 to 8 years old. In India a gram-fed sheep weighs about 35 lbs. and yields about 18 lbs. of food, and an ordinary country sheep weighs about 25 lbs.

Roughly the weight of an animal in pounds can be determined by the following formula :—

$$\tfrac{2}{3}(5L \times G^2).$$

L = the length of the trunk from front of the scapulæ to the root of the tail.

G = the girth of circumference just behind the scapulæ.

Add to the weight thus obtained $\frac{1}{20}$th of the weight for very fat animals, and deduct the same amount for very lean ones.

The animal is divided into carcase and offal; the former includes the whole of the skeleton with the exception of the head and feet, with the flesh, membranes, vessels, and fat as well as the kidneys and fat surrounding them; while the latter includes the head, feet, skin, and all the internal organs except the kidneys. Sixty per cent. of the total weight of an animal can be utilised as food, and five per cent. more in the case of fat animals.

The age of an animal can be approximately determined from the teeth and the rings on the horns, but dealers often file the horns.

A healthy animal should be well-nourished, its skin supple and its muscles fairly firm and elastic. It should not shiver or show any sign of pain, and should move about freely.

When lying down it should be able to get up with ease. The other indications of health are: quick bright eyes; nostrils red, bright and moist; tongue not protruding; respiration regular and easy with no foul odour in the breath; circulation tranquil; skin glossy and smooth; and excreta normal.

When diseased, the hairs stand out and are not smooth; the nostrils are dry and covered with frothy excretions; the eyes heavy, the tongue furred and hanging out of the mouth, respiration difficult and movements slow. In febrile conditions the ears and feet, and, in milch cows, the teats are hot.

Of the infectious diseases the most important are pleuro-pneumonia, cattle-plague, swine fever, actinomycosis, foot-and-mouth disease, anthrax, and tuberculosis.

Inspection of Meat.—Meat should be inspected soon after the animal is slaughtered. It takes about 24 hours for the carcase to thoroughly 'set' after slaughtering; but this varies with the temperature, moisture, etc. It should show no signs of bruises or bile stains. Fresh and good meat should not show any pitting or cracking, and should be firm and elastic to the touch, of good colour throughout, and not dark-red, livid, mahogany or very pale. The colour of the fat varies from white to yellow. A knife plunged into the meat and withdrawn should smell sweet in good meat. The juice should be reddish and acid, alkalinity is a sign of decomposition.

Of greatest value to the inspectors is the interior of the chest. In healthy animals this is perfectly smooth and the ribs with the intercostal muscles are clearly visible. If the inside is rough and the lining membranes cloudy, it indicates the animal had suffered from an inflammatory affection. The lungs should be spongy, of a bright pink colour, and a small piece should float on water. They should be free from cavities, nodules, pus, etc. The liver should be dark brown in colour and sufficiently hard not to break easily on pressure. The alimentary canal should be free from any appearance of inflammation and should not smell of drugs.

Characters of good Meat.—The following are the characteristics given by Dr. Letheby:—

1. It is neither of a pale pink colour nor of a deep purple tint, for the former is a sign of disease, and the latter indicates that the animal has not been slaughtered, but has died with the blood in it, or has suffered from acute fever.

2. It has a marbled appearance, from the ramification of little veins of fat among the muscles.

3. It should be firm and elastic to the touch, and should scarcely moisten the fingers; bad meat being wet, sodden and flabby, with the fat looking like jelly or wet parchment.

4. *It should have little or no odour, and the odour should* not be disagreeable; for diseased meat has a sickly cadaverous smell, and sometimes a smell of physic. This is easily

discoverable when the meat is chopped up and drenched with warm water.

5. It should not shrink or waste much in cooking.

6. It should not run to water, or become very wet on standing for a day or so; but should, on the contrary, be dry upon the surface.

7. When dried at a temperature of 212° or thereabouts, it should not lose more than 70 to 75 per cent. of its weight, whereas bad meat will lose as much as 80 per cent.

When meat is commencing to putrefy it becomes pale, moist, doughy, smells sickly and offensive, and gradually turns greenish. The cellular tissue between the muscles softens and they are easily torn when stretched.

Cysticerci cellulosæ and *Trichina spiralis* when present are found in the muscles. The cyst of cysticercus is oval and varies from $\frac{1}{20}$ inch to $\frac{1}{2}$ inch in its long diameter and represents an encysted larva of *T. solium*. Under the microscope the larva presents a square-shaped head with a sucker at each angle, within the circle of suckers are two successive rows of hooklets. To find out trichina a thin section of the muscle should be placed in liquor potassæ for a few minutes till it becomes translucent, when the coiled embryo will be seen inside its capsule.

Diseases produced by Unwholesome Meat.—Meat decomposes readily in the tropics. It is advisable, therefore, that it should not be kept long but cooked and eaten the same day the animal is killed. Particular care should be taken for the proper storage of meat, which should be protected from flies, cockroaches, and other insects.

Meat, if decomposed, may irritate the gastro-intestinal canal and give rise to certain symptoms, *viz.* nausea, vomiting, abdominal pain, diarrhœa, severe prostration and even collapse, but unless the meat is infected it rarely gives rise to any symptoms of poisoning. Urticarial and erythematous rashes very often develop, or there may be fever and delirium. By cooking the microbes are destroyed, but the symptoms of poisoning are due to infective organisms (*B. enteritidis*) and their toxins. With the exception of tuberculosis and anthrax, meat is not likely to convey any infective disease. *Tinned meats*, etc., often contain sporing organisms of the *B. subtilis* and *mesentericus* groups. A severe outbreak of food poisoning occurred in 1922 at Loch Maree, the causative organism being *B. botulinus* conveyed by eating potted food kept in sealed jars (*see* p. 158). The meat of animals killed by arsenic or other poisons may produce toxic symptoms.

The flesh of animals suffering from such diseases as anthrax, rabies, glanders, general tuberculosis, etc., should be condemned together with those killed by accidents and lightning. The flesh of pigs infected with *Cysticerci cellulosæ* and

Trichina spiralis should be avoided. *Distomum hepaticum* is very common in sheep in India.

Tuberculosis in Animals.—Cattle, pigs, poultry, and rarely sheep suffer from this disease. The Local Government Board in England have adopted the following recommendations of the Royal Commission on Tuberculosis as a guide to Meat Inspectors in the inspection of tuberculous carcases of cattle:—

(*a*) When there is miliary tuberculosis of both lungs. (*b*) When tuberculous lesions are present on the pleura and peritoneum. (*c*) When tuberculous lesions are present in the muscular system or in the lymphatic glands embedded in or between the muscles. (*d*) When tuberculous lesions are present in any part of an emaciated carcase.	The entire carcase and all the organs may be seized.
(*a*) When the lesions are confined to the lungs and the thoracic lymphatic glands. (*b*) When the lesions are confined to the liver. (*c*) When the lesions are confined to the pharyngeal lymphatic glands. (*d*) When the lesions are confined to any combination of the foregoing, but are collectively small in extent.	The carcase, if otherwise healthy, shall not be condemned, but every part of it containing tuberculous lesions shall be seized.

Cooking of Meat.—This is done for the purpose of developing the flavour and improving the appearance of meat by destroying its colouring matter and making it tender. It sterilises the meat and lessens the risk of infection by any pathogenic germs or other parasites which may be present. It diminishes the amount of water even when meat is boiled. The connective tissue must as far as possible be converted into gelatin, but meat being a bad conductor, the heat must be applied slowly and the process consequently must be prolonged. Part of the extractive matters are removed by cooking and this occurs to a certain extent even in the process of roasting. The extractives are the chief constituents of soup; they possess little or no nutritive value and yield no potential energy, although they relieve a feeling of fatigue. As it tastes and smells agreeably, soup aids digestion and is useful in the beginning of a meal.

If it is desired to make soup, beaf tea or chicken broth it is obvious that we want to extract all we can. The meat should be chopped fine and put in cold water and then raised to boiling which is continued till all nutriment is extracted from meat and bone.

If the meat is to be eaten it is necessary to conserve all the value of the meat.

(*a*) To boil meat or fish plunge into boiling water to coagulate surface albumin and then keep the pot simmering at a temperature below boiling.

(*b*) To roast meat it should be placed in front of a very hot fire and rotated. This coagulates surface albumin, and the process continued without loss of valuable juices.

(*c*) To fry, oil or fats are used, which can be raised to a high temperature.

Changes taking place during roasting are :—

(1) The extractives are drawn to the surface and are utilised for basting.

(2) The muscular bundles swell and break up and the myosinogen coagulates to myosin.

(3) Connective tissue is gelatinized.

(4) Fats are melted and break out from connective tissue over the surface of the meat and prevent it from getting dry in the cooking process.

Digestibility of meat.—Both the mechanical and the chemical parts of digestion are performed by the stomach, which renders the chief nutritive constituent of meat (protein) fit for absorption. During the process of digestion the fibres swell up and become soft, greyish-yellow in colour and pulpy. Meat with thin short fibres is more easily digested than that whose fibres are thick and long. Lean meat is more digestible than fat meat. Chicken and poultry are amongst the most digestible of all meats. But the digestibility largely depends upon its quality and the manner of cooking. Jessen has found that $3^1/_2$ ounces of beef disappeared from the stomach at different times, depending on the method of cooking, thus :—

Raw beef	2 hours
Half boiled	$2^1/_2$,,
Wholly boiled	3 ,,
Half roasted	3 ,,
Wholly roasted	4 ,,

Common Forms of Meat

Beef.—It is very extensively used, being cheaper than mutton. But the flesh varies in quality according to the part used ; rump, sirloin and fore ribs being considered the best. Beef is more strengthening, but requires strong digestive powers.

Veal is the flesh of calves and is less nutritious and less easily digested than the flesh of the adult animal.

Mutton.—This is more easy of digestion and is largely used in India. Its fibres are shorter and more tender, but it contains a larger proportion of fat than beef, and is consequently not suited for invalids. According to Jessen $3^1/_2$ oz. of raw mutton are digested in the same time as an equal

weight of beef. The flavour and digestibility often depend upon the breed of the sheep, and their pasturage.

Pig.—This is comparatively less used in India, as Hindus, Mahomedans and Jews do not take it. On account of the large quantity of fat it contains, pork is the most difficult of all meats to digest; $3^1/_2$ oz. requiring three hours for digestion, as against two hours for beef. Bacon is more digestible as the fat is in a more granular form. Like all fat meat, pig flesh contains less water. It is usually taken boiled with other lean meats like turkey, chicken, veal, or with eggs and vegetables, like peas, beans, etc. The pig is liable to be affected with the *Cysticercus* of *Tænia solium* forming "measles," and this measly pork gives rise to a form of tape-worm—*T. solium*. It is further affected with *Trichina spiralis*, causing the disease known as "trichinosis."

In the tropics generally the pig is a foul feeder and scavenger, and hence it is considered not suitable for food. Its flesh is known at times to have produced intestinal disturbances. The Chinese are very fond of pork, but they generally cook it well (Simpson).

Goat.—This is largely used in India, especially by the Hindus. Its fibres are shorter, more tender than either beef or mutton, and contain less fat, consequently goat flesh is more easily digested. The goat is immune to tubercular diseases.

Poultry and Game.—These are very favourite forms of food; but in general aspect the flesh differs from that of ruminating animals. The flesh of birds differs from that of mammals in not being permeated by fat, consequently it is easily digested. The food on which these birds are fed makes a great difference in the character of the flesh. The flesh of the fowl, guinea fowl, turkey, and partridge is white, tender, of delicate flavour, and easy of digestion; the flesh of ducks and geese is darker, and is well-known to disagree with delicate stomachs. Game birds contain less fat than poultry. Of the game birds there are many varieties in all parts of India, and these are largely eaten and esteemed as wholesome and delicate food. Partridge, snipe, quail, pigeon, wild fowl, etc., have distinctive characteristics of their own.

Liver.—This is an important article of food and contains vitamins A, B, C and D, being especially rich in vitamin A. Liver protein is easily utilised and contains valuable mineral elements, chiefly manganese and iron. The former stimulates growth, while the latter enters into the composition of hæmoglobin. Besides being an important article of food its value in the treatment of pernicious anæmia and sprue is now recognised.

Fish

Fish plays an important part in the ordinary food supply of India, and makes a welcome addition to the monotonous

diet. It has a very high nutritive value, though not so stimulating as meat, but in general it is less rich in fat than ordinary meat. Fish contains all the vitamins except vitamin C. It also contains iodine, sea-fish being specially rich. The flesh of many fishes has a peculiar odour, and different kinds vary greatly in their nutritive value, quality and digestibility. There are two classes of fish : *fat* and *lean*. Those that contain less than 2 per cent. of fat are known as lean fish ; "kai" or climbing perch *(Anabas scandens)*, and "magur" belong to this group. Those containing 2 to 5 per cent. or more of fat are grouped as fat fish.

Fish is poorer in extractives and therefore less stimulating than meat, but as it is digested more rapidly it is especially suited for invalid food, when stronger kinds of animal food are not so well digested. *Lean fish* is easily digested as the fibres are shorter and there is a comparative absence of fat. *Fat fish*, on the other hand, is very difficult to digest, and the oil is apt to get rancid and cause irritation of the stomach. Dried or salted fish is less readily digested than the smaller or younger ones.

Sea fish are more palatable but cannot be procured in parts other than in sea side districts. The common salt water fish are *Clupea ilisha* or Hilsa (Indian salmon), Sier fish, *Cybium commersonii*, though found in Asiatic waters are also found in Zanziber and off the East African Coast. Species of Mullet and of Pomfret, are also eaten either fresh or salted. The famous Bombay Duck, *Harpodon nehereus*, is a sea fish.

The tropical seas of Africa also furnish many excellent fish, *e. g.* the Sier fish and various species of Pomfret.

Rohu is one of the best known fresh-water fishes found in India and Burma. The Carp family also furnish good edible fishes, *e.g.*, katla. The mango or topsi is also a good fish highly prized in India.

Absorption of fish takes place like meat, about 95 per cent. of total solids, 97 per cent. of protein, and 90 per cent. of fat entering the blood, so that fish ranks amongst the most fully absorbed of all foods.

It is popularly believed that fish is a valuable brain food, owing to the excess of phosphates that it contains. But many doubt this statement, and are of opinion that this depends more upon the ready digestibility by persons of sedentary habits than on any other factor, and that there is no justification for the statement that fish is rich in phosphorus.

As a source of energy, its value depends on the amount of fat it contains, fat fish being equal in this respect almost to moderately fat meat. As a source of building material, fish is inferior to meat as it contains less protein. The belief that fish possesses aphrodisiac properties is a mistake ; in fact, there is no evidence in its favour, on the other hand some

authorities have pointed out that maritime populations are not especially prolific (Hutchison).

Shell Fish.—Allied to fish are lobsters, crabs, shrimps, prawns, and oysters, and they are very populur as articles of diet. These have high nutritive properties, but are less digestible. Sometimes, however, they produce symptoms of a poisonous or irritating nature, such as nausea, vomiting diarrhœa, giddiness, etc., and frequently an erythematous rash. As mentioned before, oysters when eaten raw are more easily digested than when cooked (*see* page 155). The universal custom of adding vinegar, pepper, salt, onions, etc., stimulates the secretion of gastric juice and aids digestion.

Inspection of Fish.—Fresh fish is firm, stiff and elastic to the touch, and if held flat on the hand the tail should not droop. The condition of fresh fish should be always in a state of rigor mortis, *i.e.*, should not be soft or pulpy. The eyes should be clear and bright and not dull or sunken. The gills should be bright red and not muddy, pale or discoloured. If decomposition sets in the body becomes flaccid. The skin should be intact and the scales not easily detachable in a sound fish. Soon after death the blood of fish coagulates; when decomposition begins, the blood, on cutting the fish, will run out as a dull red liquid of an offensive odour. If on removing the bones a dull red mark at the points where they touched the flesh is noted, it indicates that the decomposition is well advanced. Mussels and oysters become unfit for food very soon after death.

To avoid rapid decomposition fish should be cut open and eviscerated soon after being caught. It may be sent to distant places packed in ice.

Many parasites live in fish, but only one, *Dibothriocephalus latus*, can be conveyed to man.

Poisoning by fish sometimes occurs. Oysters frequently give rise to an urticarial rash and when taken from sewage-contaminated water may carry cholera or typhoid infection. In certain seasons, especially during spawning, fish ceases to be wholesome and acquires poisonous properties. According to Simpson, Indian mackerel and sardines on the Malabar coast are sometimes poisonous, and often the Bombay oyster causes serious illness when taken out of season, or when not absolutely fresh. Fish in any stage of decomposition should be condemned, as every hour adds to the degree of putrefaction.

Dried Fish.—It is unwholesome as it is often in a state of putridity, and when stored acts as a source of nuisance to the neighbourhood, as the smell arising from it is offensive and sickening.

Tinned Meat and Fish.—This is often dangerous in tropical climates, for it not infrequently gives rise to symptoms of poisoning of a very serious nature. If required, it should be bought from well reputed and respectable firms

that do not deal in old stocks. Provisions imported between the months of March and October should be avoided, as the hot voyage deteriorates their quality. They should be carefully examined before opening for consumption. This consists of the following methods :—

1. *Inspection.*—Look for indentations, holes or signs of gross ill-use. Presence of rust should be looked upon with suspicion as it may cause perforation. The most important sign is the bulging of the tin, indicating decomposition and formation of gas. The presence of more than one soldered hole in an otherwise good tin has no significance. They should look fresh and new.

2. *Palpation.*—Entrance of air through a leak in the tin gives it a springy feel due to loss of vacuum. A sense of resistance will be felt if there is internal pressure due to gas formation.

3. *Percussion.*—A tympanitic note indicates an unsound tin, while a dull note indicates a sound tin. This method is of little value in case of canned fruits.

4. *Shaking.*—Canned meat produces no sound on shaking, but when the contents are in an advanced stage of decomposition and partially liquid then a loose sloppy sound is detected.

On opening the tin the whole of the contents should be taken out at once. Sardines, salmons, herrings, oysters, etc., are extensively imported into India; of these sardines, owing to the amount of oil contained in the tin, are less likely to cause poisoning and are much better than other fresh packed tinned fishes, especially salmon.

Cooking of Fish.—This depends upon the kind of fish used. Oily fishes are best boiled, and this makes them more wholesome. Frying in oil is the common practice with the Indians. The secret of frying consists in sudden exposure of the fish to a very high temperature, which has the effect of coagulating the proteins on the surface and any escape of soluble substances is thus prevented. Cooking of fish should be avoided in either brass or copper vessels. When copper vessels are used they are usually, tinned inside, with what is commonly known as "kalai," but this should be always of tin, and not an alloy of tin and lead. Aluminium and iron vessels are better and less dangerous than copper ones, for in the presence of acids like vinegar, lemon, etc., copper forms a compound, acetate of copper, which is a powerful gastro-intestinal irritant, whereas with aluminium it forms alum, which is an astringent, and, therefore, harmless.

EGGS

The egg is a typical example of food containing all the proximate principles necessary for the growth and development of the body. It is however deficient as regards

carbohydrates. An ordinary hen's egg weighs about 1¾ ounces; of this about 12 per cent. consists of shell, 58 per cent. of white, and 30 per cent. of yolk. The shell consists of carbonate of lime, and the white with the yolk consists principally of nitrogenous elements. The white is made up of a solution of various proteins, the chief being egg-albumin. The yolk contains a large quantity of fat and a considerable proportion of lecithin, a phospho-protein called vitellin, and organic compounds of phosphorus and iron. The yolk contains less albuminous matter and does not so readily solidify with heat. As it contains a large quantity of oily matter, it floats in the white.

The comparative analysis of a hen's egg is as follows:—

	Water.	Protein.	Fat.	Other non-nitrogenous matter.	Mineral matter.
White .	85.7	12.6	0.25	...	0.59
Yolk ...	50.9	16.2	31.75	0.13	1.09

The egg is almost completely absorbed in the intestines, only 5 per cent. of residue being left. The value of one egg as food is equal to half a tumbler of good milk, and the potential energy yielded amounts to 70 calories.

It is a known fact that mineral matters are more readily absorbed when they exist in organic combination. Hence iron in the yolk of eggs is absorbed very easily. Yolk of eggs is therefore a valuable food for anæmic patients. It is also very rich in calcium; in fact, except milk, no food contains so much lime salts in such an assimilable form. The yolk is rich in both the *antineuritic* and *antirachitic vitamins*.

The *digestibility of eggs* depends upon the form in which they are eaten. Raw eggs are not all digested in the stomach; this is perhaps due to the fact that being bland they hardly excite gastric secretion. The following table from Hutchison shows the length of time eggs remain in the stomach under different conditions of cooking:—

2 eggs lightly boiled	... ...	1¾ hours
2 eggs raw	... .	2¼ "
2 eggs hard boiled	... ...	3 "
2 egg omelette	... ...	3 "

If hard-boiled eggs be finely divided and masticated they can be disposed of as easily as soft-boiled eggs. If the absorption of eggs from the intestine is delayed, decomposition ensues with production of H_2S and ammonia.

Eggs are preserved for a long time by preventing the entrance of air through the pores, by thoroughly smearing the shell when fresh with wax, gum, butter, lard and oil, or by immersing in a solution of sodium silicate.

Decomposed eggs are detected by placing them in a salt solution (about 2 oz. of salt in a pint of water) when they float. Fresh eggs are always heavier than stale ones. Hold an egg before a candle or a light, if fresh, it is translucent in the centre ; if stale, at the poles.

Milk

Milk is an ideal food and contains all the proximate principles of a well-balanced diet ; in fact it forms the only diet for children up to the age of eighteen months. It is the secretion of the mammary glands and exists in the form of an emulsion of fat containing proteins, salts, and carbohydrates held in solution in water. The average percentage composition of various kinds of milk commonly used by man is given in the following table :—

Kind of milk.	Protein.	Fat.	Carbohydrate.	Salts.	Water.
Human ...	2.97	2.90	5 87	0.16	88.0
Cow ...	4.0	3.7	4.8	0.7	86.8
Buffalo ...	4.4	9.0	4.8	0 8	81.0
Ass ...	1.79	1.02	5.50	0.42	91.17
Goat ...	3.62	4.20	4.0	0.56	87.54

In milk we have the different classes of alimentary principles necessary for health, but the relative proportions are not so well suited for adults under normal conditions, an excessive amount of water and albuminoids inducing too active metabolism.

The *proteins* of milk constitute about 3.5 per cent. of the total weight ; they are *caseinogen*, which forms about 3 p.c.; *lactalbumin*, 0.4 p.c.; and the remainder is *lactoglobulin*. Caseinogen is a phosphoprotein, and differs from albumin in not being coagulated by heat. It is, however, readily coagulated by weak acids and rennet. Casein is kept in solution with phosphate of lime.

The chief *mineral matter* of milk is phosphate of calcium (which occurs partly in combination with citric acid and the rest as phosphates) ; sodium and potassium chlorides, magnesium phosphate and a very small quantity of iron are also present. The iron content of human milk is two to three times that of cow's milk. Stockman has shown that 5 pints of milk are required to supply the necessary amount of iron for an adult every day.

The *fat* of milk is composed mainly of the glycerides of butyric, palmitic and oleic acids. It exists as globules of various sizes in the form of an emulsion, and constitutes about 3½ to 4 per cent. of the total weight. When milk is

allowed to stand for some time the fat rises to the top as cream bringing with it most of the bacteria. The natural colouring matter of milk (lipochrome) rises with the fat and a bluish fluid remains. The minimum legal standard of fat in England is 3 p.c. Good milk contains about 8 to 12 per cent. of cream. Skimmed milk from which the cream has been removed, contains about 1 per cent. of fat, and is not of much value for healthy people, but is better adapted for weak stomachs. As it contains all the nitrogenous elements it is far more nutritious than whey. Experiments made on children by the Scottish Board of Health have shown that separated milk, *i.e.*, machine-skimmed milk was as good for producing accelerated growth as whole milk (except in the youngest children).

The *carbohydrate* of milk is lactose or milk sugar, which is slightly sweet but extremely hard and gritty. It is present to the extent of from 4 to 5 per cent, and remains dissolved in the fluid after casein and the fat globules have been separated. It is not prone to alcoholic fermentation, but when it is exposed to the air for some time and especially if it be warm, certain chemical changes take place, and part of the lactose is converted into lactic acid; this acid combines with calcium of the calcium caseinogenate to form calcium lactate, and caseinogen becomes precipitated. This change is due to the action of an enzyme secreted by certain micro-organisms, and does not occur if the milk is stored in closed sterilised vessels.

The *enzymes* of milk are catalytic in action. They are amylolytic, proteolytic and lipolytic. They are probably colloidal in nature or closely resemble protein and are inexhaustible in their power. They are however destroyed by heat. Peroxidase is present in cow's milk, rarely in human milk.

Vitamins in Milk.—Milk contains all the four vitamins. Vitamin A is present in considerable quantity so long as the full natural quantity of milk fat is unaffected, but removal of cream interferes with this vitamin. Moreover, when the cows receive fresh green fodder the quantity reaches its maximum. Both the factors of vitamin B are present in small quantity, just enough to balance the other ingredients of milk, but not in excess to supplement the deficiencies of vitamin B in other articles of a mixed diet. Vitamin C is present in small quantity, but the amount varies with the season and depends upon the food eaten by the cows during the lactation period. Cow's milk is fairly richer in vitamin D than human milk. Irradiation of milk by ultra-violet light greatly increases its antirachitic property by activating the ergosterol present in the milk. Similarly lactating women exposed to ultra-violet rays give milk of increased antirachitic power.

The milk sold in the Calcutta markets as cow's milk is largely mixed with buffalo's milk. Buffalo's milk has a larger proportion of total solids and fat than cow's milk, and admits of a larger dilution with water. It is therefore not so digestible or pleasant to take. The intermixture of such a milk, so highly rich in fat and coagulable casein, with cow's milk renders it unfit for use as an infant-food.

Goat's milk is also used in India especially for infants. It is richer in cream, but poorer in protein than the milk of the cow. On the other hand human milk and ass's milk are richer in sugar than cow's milk.

The richness, the colour, and flavour of cow's milk vary with the character of the food on which the animal is fed. The first part of the milk contains more water, while the last part is rich in fat. The character of the milk also varies with the class and race. In some, the milk is comparatively thicker; during the rains milk is as a rule thin, and in winter much thicker.

The use of humanised cow's milk in place of, or in addition to, breast milk is not uncommon, and it is necessary that the difference between the two should be carefully noted. Breast-fed infants get their nourishment direct from the mother, at a suitable temperature and adequately mixed without any exposure to the air. The milk contains no adulterants or preservatives, and above all is bacteriologically clean and pure. Bottle-fed infants, on the other hand, get their milk which has passed through several hands, and has been exposed to endless risks of contamination in buckets, pails, cans, jugs, etc., and admitting for a moment that it was neither skimmed, watered, nor otherwise adulterated, yet after being exposed to the dust of the streets, and to filthy surroundings of dairies, etc., it arrives in varying degrees of staleness, more or less polluted and charged with microbes.

Diseases due to Milk.—Milk is responsible for more deaths and sickness than all other foods. This is due to the fact that bacteria grow well in milk and that it is rather difficult to handle and keep it clean, fresh and in a satisfactory condition. It decomposes easily and excepting eggs is the only article of food derived from the animal kingdom which is consumed in a raw state. It is most commonly adulterated and is open to all sorts of infection and pollution.

Inflammation of the udder is associated with *streptococci*, *staphylococci*, *coli* and *lactic acid bacilli*, and milk from cows suffering from mastitis will contain enormous numbers of these organisms. *Malta fever* is due to consumption of milk of goats infected with *Brucella* (*Micrococcus*) *melitensis*. *Abortus* or *undulant fever* is transmitted to man either through direct contact with infected animals or through consumption of raw milk derived from cows infected with *Brucella abortus*. This organism is the cause of the most widespread disease of

cattle, and causes abortion in pregnant cows when infected. Sore-throat, vesicles in the mouth, or fever may be caused by drinking milk of cows infected with *foot and mouth disease. Typhoid, paratyphoid, diarrhœa, diphtheria, scarlet fever, dysentery* and *cholera* are frequently due to drinking of milk contaminated with these organisms through carriers, contacts, flies, dirt, missed cases, etc. Infection may be caused by the use of contaminated water either for washing the utensils or for adulterating the milk. Except tuberculosis and undulant fever, where the germs are conveyed directly through the milk, all other diseases are due to infection of the milk with the different specific organisms.

It is obvious that there must be a grave danger of contamination of milk when proper care is not taken to obtain it under cleanly condition. Milk is one of the best culture media for pathogenic bacteria. The only important communicable disease common to man and cattle is tuberculosis. A large number of milch cows are more or less affected with tuberculosis in Europe, but not so in India.

Milk-borne epidemics have the following points in common :—

1. The epidemics have an explosive onset, they come on suddenly and disappear gradually.
2. The number of persons infected varies, but all the cases occur simultaneously.
3. The outbreaks last only a short time and extend over a definite area. Thus several members of the same family are attacked at one and the same time.
4. Children being milk drinkers are more frequently attacked than adults. For the same reason the outbreaks are more common amongst rich people who drink milk more freely than the poor.
5. The average number of cases in each house is greater than what might have been ordinarily. An average of two attacks in a house may be considered high.
6. There will be found a common milk-supply among a large proportion of the infected houses.

Adulteration of Milk.—The value of milk as an article of diet in India cannot be over-estimated. Just what meat is to the Europeans is milk to the Indians. It is of vital importance that the supply should as far as possible be pure and wholesome. Unfortunately adulteration is the rule, and a pure supply is found under exceptional circumstances.

The adulterants commonly used are :—

1. Water, which is very often polluted.
2. Cane sugar or *batasa*, a preparation of treacle.
3. Cream is very often removed, and water added subsequently to maintain the specific gravity ; or the evening milk after the removal of the cream is mixed with the morning milk.

4. Starch, flour, or arrowroot are often added to milk.
5. Milks of different animals are mixed together, *e.g.* that of buffalo with cow's milk.

Preservatives in the form of borax, boric acid, formalin, etc., are not as a rule used in India.

Examination of milk.—A sample of good milk should be opaque, of white colour, without any deposit or peculiar taste or smell. Fresh milk is amphoteric, due probably to acid phosphates of alkalies; it however soon becomes acid. When the acidity amounts to 0.4 p.c. lactic acid it is appreciable to taste, and when it reaches 0.6 p.c. it curdles. The *specific gravity* varies from 1027 to 1034, and lessens with the increase of fat, and falls one degree for each rise of 10° F. above 60° F. This is usually estimated by the lactometer which is a satisfactory guide when milk is adulterated with water only. But if sugar is added, or if water is added after skimming, then its determination cannot be taken as a reliable index of the character of the sample. The examination should be made at a temperature of 60°F. Insoluble dirt is always present in milk to a certain extent. It is largely manurial in origin and is estimated by allowing a known quantity of milk to stand for some time and then weighing the residue. Houston advocated the measurable amount to be less than 10 parts per 100,000.

When milk, adulterated with water, is placed in a white vessel, a pale blue line can be seen where the surface of the milk touches the vessel. This can be easily detected by the naked eye so long as the amount is about one-fifth of the total volume of the milk.

Cane sugar as an adulterant is detected by adding an equal quantity of diluted hydrochloric acid and a few grains of powdered resorcin to the milk and heating it, when a blood-red colour is produced. The total solids should not be less than 11.5 per cent., but generally they are 12 to 13 per cent.

The presence of starch is detected by adding a solution of iodine, which colours it blue.

Fat in milk is detected by general methods, of which Leffmann-Beam's process is the best.

Preservation of Milk.—Milk can be preserved by:—

1. *Pasteurisation.*—This means destruction by heat of pathogenic organisms which may be present, or reduction of the number of other organisms, specially those which cause milk to sour, without altering appreciably the physical and chemical characters of the milk. This is done by heating to not less than 145°F. and not more than 150°F. for 30 minutes. If the temperature is raised to 150°F. and kept for 30 minutes a small proportion (5 p.c.) of milk albumin is rendered insoluble. It does not sterilise the milk and is not a cure for dirty milking methods. It has the advantage over boiling

in that the enzymes are not destroyed, nor does it alter the appearance, taste, flavour and the nutritive value of the milk, and except the antiscorbutic vitamin, which is sensitive to heat above 122°F., other vitamins are not affected. A large variety of appliances have been devised for the purpose of pasteurisation, of these the "holder" type is quite satisfactory. Sometimes milk is pasteurised in air-tight stoppered bottles; this keeps milk sterile for a longer period than when pasteurised in bulk. But for this purpose special apparatus is required which must ensure that the milk is not heated above 145°F. to 150°F. and there must be means of ascertaining definitely that the milk has been kept at the required temperature for 30 minutes. In the "flash" type the milk is very rapidly heated to a relatively high temperature 160 to 165°F. and then cooled. This does not give satisfactory result. The simplest form of "holder" type consists of a cylindrical tank surrounded with a water jacket into which steam is admitted to heat the milk. When the milk reaches the pasteurising temperature the steam is cut off and the milk kept in the "holder" for 30 minutes and then it is cooled by a flow of cold water through the jacket.

2. The addition of peroxide of hydrogen, and heating to a temperature of 51°C. for three hours. Milk so heated is known as "Buddeised," and remains normal in taste and keeps fresh for about a week.

3. *Electrical treatment.*—Attempts have been made to sterilise milk by means of electric current without detriment to the quality which may occur from heat treatment. It is however a complicated and expensive method.

4. *Drying.*—This is generally done by (1) passing the milk through steam-heated rollers or rotating drums so as to reduce it to a fine powder. It forms a thin film which is scraped off the drum and powdered; (2) evaporating the milk in a partial vacuum which is then forced by pressure through a narrow opening into a stream of hot dry air at a temperature of 115° C. The average percentage composition of dry milk is protein, 24.3; fat, 28.5; sugar, 36.8; water, 4.8. The vitamin content of dried milk is variable and depends on the vitamin content of the original milk, method adopted in drying, and the age of the dried milk. When using dried milk for infants it should be supplemented with orange juice, cod-liver oil, or irradiated ergosterol to ensure sufficient supply of the vitamins.

5. Addition of *antiseptics, e.g.*, formalin, boric acid, etc. Under the English Law no preservatives are allowed to be mixed with milk or any of the milk products.

Effects of Heat on Milk.—When boiled in an open pan milk forms a thin skin on the top; this surface film consists of salts of lime with fat, partly dried casein, and coagulated lactalbumin. When heated for a long time the vitamin

content is lowered, it becomes thicker in consistency, brownish in colour, and altered in taste. The change in colour is due to caramelisation of lactose, and this thickened or condensed milk, commonly known as "Khir," is widely used in India as a delicacy. But the most important effect of boiling milk is that it is rendered sterile. The changes brought about in the milk by heating depend upon the degree of heat and the length of exposure. Heat lessens the stability of the colloids and increases the size of the protein particles. The chief chemical change is the precipitation of calcium and magnesium. The soluble calcium salt is reduced from about 26 p.c. of the total calcium in the fresh milk to about 20 p.c. in pasteurised milk, and to 15 p.c. after one hour's boiling. This lowering of soluble calcium diminishes the metabolism of calcium, phosphorus and nitrogen of the body. Heat also reduces the iodine of separated milk by volatilization by 20 p.c. or more according to the duration, leaving the ratio of diffusible to non-diffusible iodine unaltered.

Digestibility of Milk.—It should be noted that milk, though a fluid, is rendered practically solid after it reaches the stomach. During digestion the gastric juice curdles the milk; the curdling is due to the change brought about in the casein by rennin. The casein of cow's milk forms dense and hard curd, whereas the coagula of human and ass's milk are softer and flocculent. The curds later on are changed into albumoses and peptones by the digestive ferments.

Citrate of soda prevents coagulation of milk by converting soluble lime salts into insoluble calcium citrate. Aeration by the use of sparklets is an important factor in avoiding clotting. The digestibility of milk depends on the density of the clots in the stomach. The formation of large dense clots can be avoided by taking milk in sips, when the milk is broken up in the stomach and does not form hard clots. It has been found that it takes about two hours for a glass of milk to leave the stomach, but the condition of the milk has a great influence on the duration of its stay, thus:—

602 c.c. (about a pint)		raw milk	leaves after	3	hours
,,	,,	skimmed	,,	$3\frac{1}{2}$	,,
,,	,,	sour	,,	3	,,
,,	,,	boiled	,,	4	,,

The digestion of milk is completed in the intestines by the pancreatic juice, which acts more powerfully on milk than gastric juice. Absorption of milk is more or less complete; in fact, the protein and fat are absorbed as well as, or even better than, the protein and fat of beef (Hutchison). But when milk forms the only diet of an adult it is not so readily absorbed. Under normal conditions about 90 per cent. of the available potential energy reaches the blood. Milk is absorbed with less expenditure of energy than any

other food ; in other words, there is less wear and tear of the intestines.

Graded Milk.—Under Milk (Special Designations) Order 1923, four main grades of milk, *viz.* Certified, Grade A, Grade A (tuberculin tested) and Pasteurized have been sanctioned in England. The conditions under which licences for selling the different graded milks may be granted are :—

1. *Certified.*—Each cow is examined every three months, and tuberculin tested every six months. No fresh animal is to be added to the herd unless tuberculin tested within three months. Animals giving positive reaction are to be removed from the herd, and any animal showing clinical signs of disease should be isolated or removed. The milk should be bottled on the farm immediately after production, and the bottle sealed by a suitable disc and covered with a cap. The cap shall bear the name and address of the producer, the day of production, and bear the words "certified milk". Milk may not be treated by heat.

Grade A.—Every animal is examined every three months and any showing evidence of disease is isolated. Milk from isolated cows may not be sold as Grade A milk. If tubercle bacilli are found in the milk of a cow steps should be taken to ascertain which animals are diseased and to remove them. The herd must be kept separate from all other cattle. Milk should be sent out in sealed containers bearing the words "Grade A" milk as in case of "Certified Milk". If not it should be put up in other suitable containers of not less than 2 gallons capacity, tightly covered and sealed and labelled.

Grade A. (Tuberculin tested).—As for Grade A milk with the addition that every cow is tuberculin tested every six months.

Grade A Pasteurized.—Milk to be retained at a temperature of 145° to 150° F. for at least 30 minutes and then suddenly cooled to temperature of not more than 55° F. The milk should not be treated otherwise than by heat, and should not be pasteurized more than once.

Bacterial content :—

Designation.	No. of bacteria per c.c.	No B. coli in
Certified	30,000	0.1 c.c.
Grade A	200,000	0.01 c.c.
Grade A Pasteurized ...	30,000	0.1 c.c.
Pasteurized	100,000	—

Improvement of Milk-Supply.—This is one of the many vexed questions which requires careful study.

Two methods may be adopted for improving the quality of the milk-supply ; *viz.*—(*a*) legislation, and (*b*) instructing the dairymen in the essentials of hygienic milk production. Dairymen being illiterate, instructions can only be given by practical demonstration. Individual farms should be visited, existing conditions examined, and the special advantages of improvement explained. Practical suggestions should be given, and no one should be asked to adopt improvements which are beyond his ability and intelligence. The cleanliness of the utensils, the treatment of the milk, the local sanitation and the breeding of flies and other dangers should be carefully explained.

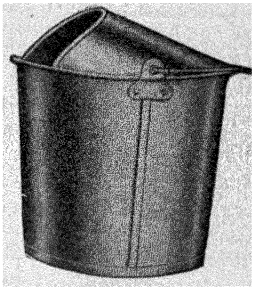

FIG.—30.

An Improved Type of Milk-pail.

The English Milk and Dairy Order, 1926, provides for the registration of dairymen, inspection of dairies including veterinary inspection, control of communicable bovine disease, prevention of the spread of human infectious disease through milk and for ensuring proper management and handling.

The following rules, if carefully followed, will effect a marked improvement in the character of milk-supply :—

(*a*) The milk should be received in clean, freshly scalded metal vessels and should be protected from flies. No chickens, cats, etc., should even be allowed in a dairy.

(*b*) The cow's tail should be secured to prevent flicking dirt attached to it during milking.

(*c*) The floor of milk sheds and the approaches to the sheds should be paved and kept as clean as possible

(*d*) All persons handling milk should be clean, should not suffer from any communicable disease, and should not be "carriers."

(*e*) The cow should be healthy and free from any infection, nor suffer from inflammatory condition of the udder. It should be properly groomed to remove dung from its body, and the udders should be properly washed

(*f*) All bottles and cans used should be washed and sterilised

(*g*) Feeding the cow during milking and putting the fingers into the milk should not be allowed.

(*h*) Do not strain, skim, or keep the milk in the cowshed.

(*i*) All refuse should be removed to a safe distance daily.

For the purity of milk-supply the following regulations of the Bengal Municipal Act, 1932 will be of interest :—

434. The Commissioners at a meeting may, and when required

by the Local Government shall, make by-laws regarding all or any of the following matters :—

(a) the registration of all dairymen, or persons selling milk, and dairies, within the municipality; (b) the inspection of dairies and dairy cattle within or without the municipality and of persons in or about dairies who have access to the milk or any milk-receptacle; (c) the duties of dairymen or persons selling milk in connection with the occurrence of infectious or contagious disease amongst persons residing or employed in or about their premises, and their duties in connection with reporting the occurrence in any dairy cattle of diseases which are communicable to man and of any disease of the udder; (d) the conveyance and distribution of milk, and the labelling or marking of receptacles used for the conveyance of milk; (e) the ventilation, including air-space, lighting, cleansing, drainage and water-supply of dairies; (f) the health and good condition of the milch-cattle in dairies; (g) the cleanliness of dairies, milk-receptacles, dairy cattle and all persons employed in or about dairies; (h) the protection of milk against infection or contamination; (i) the prevention of the sale of infected, contaminated, or dirty milk, and the closing of any dairy where such milk is kept for sale or the exclusion therefrom of any animal; (j) any other measures and precautions which in the opinion of the Local Government may be necessary to secure and maintain the purity of the milk-supply.

THE BACTERIOLOGICAL EXAMINATION OF MILK

Chemical examination of milk shows whether the milk is genuine or not but it gives no idea about its hygienic quality. By chemical analysis we get no information about the possibility of the milk containing pathogenic organisms. This is of great importance, as a number of diseases are communicable through milk; indeed milk is frequently the vehicle for the transmission of many infectious diseases to man.

The bacteriological examination of milk is undertaken for the following informations :—

1. To measure the degree of fæcal pollution.
2. To find out if disease-producing organisms like *B. typhosus*, *B. tuberculosis* and *cholera vibrios* are present; and
3. To ascertain if the udder of the animal is healthy or diseased.

Total Bacterial Count.—This is done as in the case of water, with nutrient agar medium with definite dilutions of milk. These dilutions are made as follows: A series of glass-stoppered bottles containing 90 c.c. sterile water is taken and the first bottle receives 10 c.c. of the milk to be examined; and is well shaken. 10 c.c. of this is transferred to a second bottle with 90 c.c. of water and shaken. 10 c.c. of this is transferred to a third bottle and so on. Each dilution represents one-tenth dilution of the one immediately previous to it in the series. In this manner dilutions should be made from 0.1 c.c. to 0.000001 c c. and plates made from the number of dilutions beginning from the last dilution.

The following factors influence the total bacterial count, *viz.* the method of collection, the time that has elapsed since milking, and the temperature at which the milk has been kept.

Fæcal Bacilli Count.—This is more important than the total bacterial count and should be done as described in the case of water with McConkey's broth tubes inoculated with 1 c.c. from each dilution, and incubated. The presence of *B. coli* in large numbers indicates manurial and other undesirable contamination.

Estimation of B. enteritidis sporogenes.—The spores of this organism are said to be present in large numbers in cow dung. The estimation of its numbers in milk is therefore important, particularly as it does not multiply in milk. It is tested in the same way as is done for water.

Streptococci.—These are present in milk in large numbers in cases of mastitis and ulceration of the teat. Their presence in large numbers may be taken as indicative of inflammatory disease of the milk-producing organs of the cow.

Microscopical examination of the centrifugalized and stained deposit gives an idea of the nature of cellular elements present. A high leucocyte count accompanied by streptococci usually indicates diseased udders. The presence of pus cells may indicate purulent inflammation of the udders. Both leucocytes and pus cells are however present also in the milk of healthy cows, though in much less numbers.

Tubercle Bacilli.—A portion of the centrifugalized deposit is stained and examined microscopically for acid fast bacilli by the Ziehl-Nielson method, and the rest of the deposit injected into guinea pigs subcutaneously on the inner side of the leg. A negative result microscopically is not of much significance as the tubercle bacilli are present only in small numbers. When *T. bacilli* are present, an infection takes place, the glands on the inoculated side become enlarged and the bacilli can be demonstrated from films made from them.

Derived Milks

Skimmed Milk.—This is prepared by skimming off the cream either by hand or by machinery. When made by hand it contains about 1 p.c. of milk fat. When made by a churning machine it is known as "*separated milk*" (machine skimmed milk). In this cream is separated by a centrifugal machine. It contains less fat than hand-skimmed milk, but the total solids remain the same, *i.e.* not less than 8.7 p.c.

Evaporated milk.—This is milk reduced to 50 p.c. of its original volume by evaporation.

Malted milk.—This is a powdered product made from malted barley, wheat flour and whole milk evaporated to dryness in a partial vacuum, which allows the temperature to be kept low, *i.e.*, to about 125° F. It contains fat 9.2 p.c., protein 15.5 p.c., lactose or maltose 49.1 p.c., dextrose 20.2 p.c., ash 3.8 p.c., moisture 2.2. p.c. Though not sterile it has a low bacterial content and the various heating processes are said to free it from any pathogenic bacteria. It contains vitamins A, B and C though the latter is partly destroyed.

Homogenized Milk.—In this the fat does not separate out and will not rise to the surface as cream on standing. This is effected by passing the milk under high pressure through minute apertures so that the fat globules are reduced in size and the milk becomes uniform in consistence.

Condensed Milk.—Condensed milk is extensively imported to India, and is largely used by Europeans, especially in places where fresh and good milk is difficult or impossible to obtain. Condensation is effected by evaporating the water by gentle heat. This is accelerated by the reduction of atmospheric pressure in so-called vacuum pans, and is carried so far that the volume of the milk is reduced to about a quarter. Condensed milk, therefore, represents four times its volume of fresh milk. *Dried milk* is now manufactured to take the

place of condensed milk. It is found in coarsely granular powder, and when diluted with water in proper proportions makes excellent milk (*see* page 208).

Most of the condensed milks are sweetened with sugar which helps their preservation, but the cream is often removed, and the product is really *condensed skim milk*. The following are the different varieties of condensed milk found in the market :—

1. Condensed whole milk (sweetened).
2. " " " (unsweetened).
3. " skim " (sweetened).

The sweetened milks are for the most part good, and usually contain more cane sugar than milk solids. A good specimen may contain 11 per cent. fat; 10 per cent. protein; 14 per cent. milk sugar; and 38 per cent. cane sugar. The sweetened skimmed milks, or separated milks or machine skimmed milks are very inferior to the above, and generally contain 1 per cent. of fat. Such a milk, therefore, is unfit for the sole nourishment of infants.

Humanised Condensed Milk.—This is condensed milk to which milk sugar and cream have been added. When diluted with water in the proper proportion it is practically identical with human milk in quantitative composition.

Digestibility of Condensed Milk.—Condensed milks are more digestible than pure cow's milk, as they do not form curds in the stomach at all, or if they do, the curds are more flocculent than those of ordinary milk. During condensation the casein undergoes certain chemical changes and hinders the formation of clots.

As a rule condensed milks are of less nutritive value than pure milk, due to their containing less fat. Hence condensed skim milk should be avoided, as well as sweetened whole milk For infants it is better to avoid any form of condensed skim milk. If, however, fresh milk be not available, unsweetened condensed whole milk should only be used.

Preparations of Milk

Curdled Milk, Sour Milk or Dahi.—This is fermented milk very largely used in this country, being more easily digested than raw or boiled milk. It is either sweetened or unsweetened. The sour milk owes its virtue to the production of lactic acid, but the causative element is a *streptothrix*, with characters similar to *B. bulgaris*. Professor Kitasato has shown that 0.3 per cent. of lactic acid kills the comma bacillus in 5 hours. The addition of sugar previous to curdling does not affect the amount of lactic acid, but masks the acidity and makes it palatable. When milk turns sour the proteins of milk are partly decomposed and coagulated, and the fat particles are enclosed in the coagulated casein.

Preparation of Sour Milk.—The milk is first boiled, and

when partially cooled it is inoculated with a little curd from a previous preparation as a starter of fermentation, and kept at the room temperature for fermentation to go on. Sour milk as sold in the bazaar is hardly ever made from whole milk; the milk is deprived of its fat, and the skimmed milk is utilised for its preparation.

Butter-milk or Ghol.—This is the residual milk left after butter is taken away by churning. Ghol is generally prepared in India from sour milk or *dahi*. It is a sour tasting fluid of varying consistency according to the amount of water present, with the casein of the milk existing in a finely coagulated state, *i.e.*, in a more easily digestible form than in ordinary curd. The lactose is in great part converted into lactic acid, and it contains very little, if any, fat. Butter-milk contains more protein than whey and is very nutritious. Under the name of *Eledon* butter milk is sold in the form of dry powder in hermetically sealed tins. When mixed with boiling water it forms butter-milk.

Curd and Whey.—Whey is the fluid left after the curdling of the milk. It is prepared by adding essence of rennet or some weak acid to milk heated to 140°F. By this caseinogen is first changed into soluble casein which combines with calcium to form clot. The coagulum or curd (*chhana*) is then cut into pieces, strained through *muslin*, and hung up to allow the fluid (whey) to drain away. The *curd* consists of casein and entangled fat, while the *whey* contains all the sugar, most of the mineral ingredients, and about 0.8 per cent. of protein in the form of lactalbumin. When milk is coagulated by rennet it gives an alkaline reaction and forms the so-called "sweet whey."

It has a sweetish sour taste, and with equal parts of cow's milk it almost resembles human milk in composition.

The curd of milk is commonly known as "chhana" or *khilat*. Its use is practically limited to Bengal. From this curd, which contains chiefly casein and some fat or fat globules entangled in it, a large number of delicacies such as "sandesh" are prepared by the addition of sugar, syrup, etc. It contains protein 24.06, fat 2.5, and salt 1.1.

Koumiss and Kefir.—These are in reality preserved milk containing lactic and carbonic acids and a little alcohol (1 to 2 p.c.). True *koumiss*, as prepared by the Tartars, is fermented mare's milk.

Kefir is a fermented milk like koumiss, the ferment being a Caucasian mushroom. It can also be made at home by the addition of kefir ferment.

Cheese.—It consists of coagulated casein (*chhana*) with varying proportions of water, fat, and salts. It may be made from whole milk, from skimmed milk, or from whole milk and cream. The ripening of cheese is the result of decomposition, whereby the casein undergoes a fatty change with the

formation of lime salts and fatty acids. The average composi-of a good sample of cheese is: protein, 27.0 p.c.; available protein, 25.3 p.c.; available fat, 25.0 p.c.; salts, 6.0 p.c.; Calorie per oz. 97.0.

Cheese is infiltrated with about 30 per cent. of fat, and is not easily digested by delicate stomachs. It is a cheap form of animal food of high nutritive value and is a valuable substitute for meat. In fact beef contains less than half as much nourishment as the same weight of cheese. It deteriorates rapidly in the tropics, and is chiefly adulterated with starch.

Butter.—Butter is obtained by churning either the curdled milk or the cream at a low temperature, when the ruptured fat globules clot together, entangling in their meshes water, a small amount of casein and salts. Butter is used to a much less extent by the people of this country than *ghee* or clarified butter. Butter fat contains 40 per cent. of olein and is rich in those fatty acids (butyric, caproic and capric acids) which are soluble in water. An average sample of butter contains 7.5 to 12 per cent. of water, 1.0 to 3.0 per cent. of casein, 74 to 90.5 per cent. of fat, 1.0 to 7 per cent. of salt. The percentage of water in different samples of butter, as sold in Calcutta, rarely exceeds 16, except in Ghatal (Midnapur) butter, which gives an average of 30 per cent. Butter may be preserved by the addition of salt (not exceeding 10 per cent.) or by keeping it in water.

Butter is the most easily digested of all fats. As the butter fat approximates olein of the fat of the human body, it is of great value as food. It contains vitamins A and D. Adulteration of butter is not so universal as milk or *ghee*. Water is the chief adulterant, but admixture with low grade *ghee*, animal fat, and curd are also met with. In England it is chiefly adulterated with *Margarine*, which is prepared by churning melted or clarified beef or mutton fat with skimmed milk.

GHEE

Ghee is clarified butter and is largely used in place of butter in India. It is prepared either from the milk of the cow or of the buffalo. Buffalo *ghee* is whiter in appearance, while cow's *ghee* has a faint yellowish tinge and a pleasant sweet smell.

Ghee is made from milk which is first boiled and then curdled. In about six hours curdled milk is churned after adding a little water, when the butter floats on the top. This is then collected and allowed to become somewhat rancid and then washed and heated, when the butter melts and casein and water fall to the bottom. The water is then evaporated and the casein that remains behind is burnt off. The fat clarifies on standing which constitutes the *ghee* and

when sufficiently clear is run off from the sediment. The floating *ghee* being thus free from water and organic matter can be preserved for a much longer time than butter itself. This is an important consideration in a tropical country where butter soon becomes rancid and unfit for use. *Ghee* contains vitamin D, but the ordinary method of preparing by prolonged heat destroys vitamin A present in natural butter fat. Vitamin D being more themostabile resists prolonged heating. *Ghee* is used in the preparation of various kinds of food, such as sweets, *poories*, curries, *dals*, etc.

Buffalo *ghee* contains more soluble volatile acids as determined by the Reichert-Wollny process, corresponding generally from 34 to 39 c.c. of deci-normal alkali for 5 grms, of *ghee*. In forty samples of purified *ghee* carefully prepared from pure buffalo milk in the Calcutta Municipal Laboratory for standardisation purposes, the minimum Reichert value, in terms of deci-mormal soda, was found to be 30.5, and the maximum 39.3, the average being 34.5 for 5 grms. of the *ghee*; while the minimum Reichert value for *ghee* from pure cow's milk was 22, the maximum 27, and the average 24, for 5 grms. (Simpson).

The legal standard of *ghee* is given under The Bengal Food Adulteration Act (*see* page 229). The following standard for *ghee* has been adopted by the Corporation of Calcutta:—

	Cow	Buffalo
Specific gravity	911 to 912	911 to 913
Soluble volatile acids in terms of deci-normal soda by Reichert-Wollny method	24 c.c.	30.0 c.c.
Melting-point ...	34° to 35.5° C.	34° to 36° C.
Oleo-refractometer at 45°C. ...	—32 to 35	—32 to 35
Butyro-refractometer at 40.5°C. ...	40 to 42.5	40 to 42.5

Ghee as sold in the market is almost wholly prepared from buffalo milk. Nearly 70 per cent. of the *ghee* of the Calcutta market is adulterated. The principal adulterants are ground-nut (*china badam*) oil, animal fat, mohua oil, poppy seed oil, cocoanut oil, castor oil, etc. These are not easily digested. When adulterated with animal fat it generally remains solid.

In cold weather good *ghee* should be clear, white, and solid, with a very faint agreeable odour. If dirty or bad smelling it should be condemned.

Vegetable *ghee* is now largely advertised for sale in India, it is really *vegetable fat* and is inferior to ordinary *ghee* and does not contain any vitamin (*see* p. 175). It is used as a cheap substitute for and as an adulterant of *ghee*.

The presence of vegetable oils can be detected by the following test :—

Take one part of the suspected *ghee* and four parts chloroform in a test-tube and agitate by adding a few drops of phosphomolybdic acid ; on allowing the test-tube to stand, a green ring will be noticed at the junction of the two substances.

Animal fat may be detected by the following tests:—

1. Take equal parts (3 c.c.) of glacial acetic acid and of the suspected *ghee* in a test-tube and dip it in warm water, agitate frequently and note the temperature at which the *ghee* melts. If it melts at a temperature between 29° C. and 39° C. then it may be taken as a good sample. But if the melting temperature be higher than this it indicates adulteration with animal fat. An abnormally low figure suggests cocoanut oil. This is known as the *Valenta test.*

2. Shake well in a test-tube dilute carbolic acid (9 parts of the acid with one of water) $2\frac{1}{4}$ parts, with *ghee* one part. Allow it to stand, when the animal fat will rise to the top, while the butter fat or *ghee* will be dissolved by the acid.

3. *Refractive Index.*—This is determined by means of a special instrument called refractometer. At 40° C. it varies for butter from 40 to 42. Cocoanut oil gives about 34 to 35 at 40°C.

CHAPTER X

BEVERAGES AND CONDIMENTS

BEVERAGES

BEVERAGES are substances which by enabling food to be taken with pleasure and relish act as food accessories. They stimulate digestion by acting on the digestive organs, either directly, or through the central nervous system.

Water is the universal beverage, and all other beverages contain water more or less. The utility of water in the human economy has already been discussed (*see* page 151). It must be stated here that absorption of water does not take place in the stomach at all, and no sooner does it reach the stomach than it begins to flow out into the intestines, and the rapidity with which it passes through this organ makes it a very dangerous vehicle of infection. Therefore contaminated water is more dangerous as a carrier of disease than infected milk. Roughly, it takes about an hour for a pint of water to leave the stomach. Hot water excites the movements of the stomach and tends to open the pylorus.

Aerated and Mineral Waters.—Artificial mineral waters are prepared by dissolving in water salts of soda, lime, and magnesium, commonly present in natural water, and then charging it with CO_2 gas. Mineral waters when derived from natural springs, besides containing some natural ingredients, are impregnated with CO_2 gas.

Mineral aerated waters have a sharp pleasant taste, and mineral water, of all other beverages, promotes the chemical process of digestion. The CO_2 gas by stimulating the movements of the stomach helps the mechanical process of digestion, and by lowering the sensibility of the nerves of the stomach acts as a gastric sedative. When added to milk, aerated water causes it to coagulate in small flakes, and when used with acid wines, neutralises the inhibitory action of the wine on the saliva. Aerated water is not always sterile ; excepting perhaps the comma bacillus, many organisms thrive in CO_2 gas ; moreover, aerated water is often prepared from water not always above suspicion.

Besides the above, beverages commonly used may be divided into :—

A. Non-fermented drinks, and
B. Fermented drinks.

A. NON-FERMENTED DRINKS

Tea.—A hot infusion of various plants is used as a beverage in almost all parts of the world, but the most important

and widely used of all is tea. This consists of the dried leaves of a shrub called *Camellia thea* mostly cultivated in China, Japan, India (chiefly in Darjeeling and Assam), and Ceylon. The leaves from the top of the shoot, *i.e.*, the youngest ones, containing least fibre and abundant juice, are called *flowery* or *orange pekoe* and form the best variety of tea. The leaves from just below and larger than the above set are called *pekoe*, and those lower than that are *souchong*.

The chief difference between *green* and *black* tea depends upon the time of gathering the leaves and the mode of treatment. Black tea is fermented, which renders the tannic acid less soluble. Green tea is prepared from the younger leaves, which are roasted soon after gathering. It contains more tannic acid, more volatile oil, and less caffeine than black tea ; therefore it is less stimulating and more astringent.

The *composition* of dry tea is caffeine 1 to 4 p.c., a minute trace of theophylline, and a volatile oil 0.6 p.c., which imparts the flavour and odour, and a large amount of tannic acid which precipitates albumin, gelatin and alkaloids, and is strongly astringent. But the percentage of tannin is greater in India tea, if infused long, than in China tea. During infusion about 25 per cent. of the weight of the leaves is dissolved out. Caffeine begins to dissolve out directly the infusion has started. The tannic acid dissolves slowly and the longer the tea is infused the more will the acid be dissolved.

Mode of Preparation.—The *proper method* of preparing tea should be by *infusion* and not by decoction, and the infusion should not last for more than five minutes.

Coffee.—As ordinarily used coffee is the seed of *caffea arabica*. The seeds are first roasted and then ground to powder, when they are ready for use. The roasted coffee contains 0.6 to 2 p.c. of caffeine. a small amount of caffeol and a large amount of tannic acid. Caffeol is an empyreumatic oil developed in the process of roasting. It is the source of the flavour and aroma of coffee. The tannic acid unlike that of tea does not precipitate albumin, gelatin or alkaloids, and is not astringent. The aromatic oil is very volatile and deteriorates rapidly on keeping ; coffee should therefore be prepared fresh after roasting. During infusion about 25 per cent. of the coffee is dissolved out. French coffee contains chicory, and at times burnt sugar ; in fact, coffee is largely adulterated with chicory.

Preparation of Coffee.—There are three methods of preparing coffee :—

1. *Filtration.*—In this process boiling water is allowed to percolate through finely ground coffee. Air should be excluded as much as possible, or else oxygen will alter the aroma. This process dissolves only 11 to 15 per cent. of the coffee.

2. *Infusion.*—This is the common method. It is said to

reduce the exciting influence of strong coffee without destroying its aroma.

3. *Decoction.*—This method is principally used in Turkey. The coffee seeds are ground to powder and placed in cold water which is then boiled. This is generally taken without straining.

Cocoa.—Cocoa is a powdery preparation made from chocolate by removing a portion of the fat by hydraulic pressure with or without heat. The dried residue is ground to fine powder so that it may be more readily mixed with water. The proportion of theobromine in cocoa is somewhat higher than in chocolate. It is not so widely used as tea or coffee, and not so popular a beverage with Indians. Cocoa is derived from the seeds of the fruits of the plant *Theobroma cacao.*

The beverage "cocoa" is made by boiling the powder with water or milk for at least five minutes so that its starch may be properly hydrolysed, otherwise it is nothing but a mixture from which the powder tends to separate.

Chocolate is the paste made from the ripe seeds after they have been sweated, dried, roasted and deprived of their shells. The sweating or fermentation process eliminates practically all the tannin and some of the bitter substance present in the ripe seeds ; roasting brings out the flavour. Chocolate contains theobromine 0.3. to 2 p.c., starch 10 p.c., vegetable protein 15 p.c., cocoa butter 30 to 50 p.c. It is sweetened with sugar and often flavoured with vanilla. It is highly nutritive and has been shown to be almost completely digestible.

Action and Uses of Tea, Coffee and Cocoa

Coffee and tea are not nutritive in themselves, and require no digestive process for their absorption. Addition of of milk or cream and sugar, however, changes them into food. Coffee and tea habits are common amongst brain workers. Many elderly people find tea particularly satisfying and soothing after reaching a period of life when the functional activity of the stomach is weakened. Coffee is less liable to produce flatulence than tea, and, therefore, should be preferred in cases of flatulent dyspepsia. Strong infusions irritate the mucous membrane, especially when taken on an empty stomach, and may either excite or keep up a condition of chronic gastric catarrh.

Taken in moderation tea gives a feeling of comfort and increases bodily and mental vigour. As a stimulant it differs from alcohol in that it is not followed by depression. In villages where the water-supply is not above suspicion it is always safe to have a cup of tea instead of water. Though the danger from infection through water is diminished by boiling, such water is not palatable and the addition of tea

makes it an agreeable drink. Strong infusions taken in large quantities often cause constipation. Tea should be avoided in dyspepsia, gastric irritability, constipation, anæmia, insomnia and nervousness.

Coffee causes stimulation of the nervous system, and there is a feeling of exhilaration and diminution of the sense of fatigue. Strong coffee taken after dinner tends to retard the digestive process, it should therefore be avoided by dyspeptics. Caffeine lessens the feeling of hunger but does not prolong life in cases of starvation, and it increases tissue waste. In comparative experiments with whole companies of soldiers on the march under like conditions, Leistenstrofer, on behalf of the German Government, found that when the soldiers were well supplied with food, those that were given tea or coffee could endure more prolonged and more severe marches than those that did not get tea or coffee. If no food was supplied fatigue appeared first in the tea and coffee-drinkers. Tea and coffee therefore increase the power for continuous physical work so long as the supply of nutritive material is ample, but cause early exhaustion when food is withheld (Bastedo). Excess of coffee drinking causes nervous disturbances, palpitation, insomnia, and liability to attacks of neuralgia.

From the chemical composition of cocoa it appears to be a valuable food of much nutritive value ; a cupful of beverage prepared as above with about 10 grms. of cocoa gives a nutritive value of about 150 Calories. Such a drink may be taken by invalids for its food value. Chocolate, however, is of more value, and half a pint of milk and two ounces of chocolate yield about 400 Calories.

Sherbets.—These are non-aerated sweetened drinks widely used in India as refreshing and cooling beverages, especially in summer. They are ordinarily prepared by dissolving sugar, sugar candy, etc., in water and flavouring with either lemon juice or some other flavouring agents.

Cocoanut Water.—This is largely used in certain parts of India, especially in Bengal; as a refreshing drink, and is useful in cases of acid dyspepsia, especially when taken after meals. It has an acid reaction with a specific gravity of 1020 to 1030, and contains 0.92 per cent. of protein, 0.62 per cent. of carbohydrates, and some salts. When good water for drinking purposes is not available it is always safe to use cocoanut water.

B. Fermented Drinks

Almost all fermented drinks contain a chemical substance of a powerful nature commonly known as *alcohol*. The distinctive character of alcoholic drinks depends on the particular kind of sugar or yeast used in their fermentation.

Alcohol consists of three elements, *viz.*, C, H, and O, and

is represented by the formula C_2H_6O. It is generally prepared by the fermentation of sugar by which it is split up into alcohol and carbonic acid as follows:—

$$C_6H_{12}O_6 = 2C_2H_6O + 2CO_2.$$

Pure alcohol is lighter than water and mixes with it very readily. It is very inflammable, and when mixed with water heat is evolved. When more water is added it burns less readily, and finally it does not burn at all. The term *proof spirit* owes its origin to this property of alcohol. Alcohol when weaker than proof spirit is known as *under proof*, and when stronger as *over proof*.

Alcoholic beverages for convenience of description may be grouped under the following heads:—

I. Beer or Malt Liquors.—Under this head are included beer or ale, porter or stout. Beer is the product of the fermentation of malt and hops. Porter and stout are prepared almost in the same way as beer, but the malt is first roasted like coffee, and the colour is due to caramelisation of sugar.

The chief constituents of malt liquor are: alcohol, dextrine, sugar, vegetable acids and some soluble nitrogenous matter.

II. Spirits.—The chief difference between spirits and other alcoholic beverages is that the former are products of distillation and contain a certain percentage of alcohol. Roughly, spirits are compounds of alcohol and water, but each kind has its characteristic flavour due to the fermentation of various bye-products during the process of preparation. By the use of patent stills these bye-products can be separated from the alcohol which is consequently pure and without any flavour when it is called "silent spirit." Spirits are prepared by fermentation of various saccharine substances, and any substance capable of yielding fermentable sugar may be utilised in their manufacture.

(*a*) *Whisky.*—This is often described as a spirit obtained from fermented grain by distillation, and contains from 48 to 56 per cent. by volume of alcohol. It should be free from disagreeable odour and not less than two years old. There are two kinds of whisky:—

(*i*) *Malt Whisky* made from malted barley in pot stills; the peculiar smell is derived from the peat smoke.

(*ii*) *Grain Whisky.*—This is prepared from cereals—barley, rye, or maize—to which a little malt is added to convert the starch into sugar. These are distilled in patent stills by which some of the bye-products of fermentation (fusel oil, etc.) are also separated.

(*b*) *Brandy.*—This may be defined as a distilled wine, and therefore varies in quality with the character of the grapes used. When freshly distilled it is colourless and very strong. It improves with age due to the formation of volatile ether and aldehydes. Ordinarily it is not distilled from wines but prepared from "silent spirits" and coloured with burnt sugar, and flavoured. When prepared from wines it is one of the purest and least injurious form of spirits, and usually contains 45 to 55 per cent. of alcohol.

(*c*) *Rum.*—It is prepared by the fermentation of molasses, but the best variety is obtained from the direct fermentation of the juice of sugar cane. The colour is due to burnt sugar and improves in flavour by the development of ether. When kept in oak barrels it acquires an astringent property and is less irritating to the stomach. It contains from 50 to 60 per cent. of alcohol.

(*d*) *Gin.*—This is obtained by the fermentation of a mixture of rye and malt and flavoured with juniper berries, cardamoms, and other aromatics. It contains 40 to 50 per cent. of alcohol.

(*e*) *Liqueurs.*—These are spirits sweetened with cane sugar and

flavoured with aromatic essences and contain about 33 to 35 per cent. of alcohol.

III. **Wines.**—Wine is the result of fermentation of grape juice, and in case of sparkling wine, of a secondary fermentation of added sugar. The chief constituents of the juice concerned in the fermentation are: sugar—which is a mixture of grape sugar or dextrose, and a fruit sugar or lævulose—albuminous matter, tartaric and tannic acids. The presence of albuminous matter is important, for the yeast lives on it and splits up sugar. Natural wines can never be stronger than 16 per cent. of the volume for the accumulated alcohol has a paralysing effect on the yeast. If the wine contains more alcohol spirit must have been added, when it is called "fortified wine." Substances which influence the action of wines are:—

1. Ethylic alcohol and other alcohols.
2. *Acids.*—Tartaric, tannic, and malic acids are the natural acids; tartaric acid is present in the form of bitartrate of potash.
3. *Sugar.*—A natural wine contains about ½ per cent. of sugar, fortified wines in which the fermentation has been checked contains as much as 2 per cent.
4. Ethers are produced by the action of alcohol and acids, and two varieties, *viz.*, volatile and fixed ethers, are present.

The principal natural wines are:—

Claret, containing 8 to 13 per cent. of alcohol by volume.

Burgundy resembles claret. It contains a higher percentage of alcohol and is richer in extractive matters.

Hocks are pale wines and have the strength of claret.

The fortified wines are:—

Sherry contains about 15 to 22 per cent. of alcohol by weight. With age sherry develops a larger proportion of volatile ether than any other alcoholic liquor.

Port Wine contains 19 to 20 per cent. of alcohol by weight.

Champagne is prepared from black grapes. Strictly speaking it should be a natural wine with 9 to 12 per cent. of alcohol by weight.

IV. **Country Spirit or Arrak.**—These are prepared by fermentation of either rice, mohua (*Bassia latifolia*), molasses or *gur* (treacle). In case of molasses, *gur* or *mohua* the sugar is already formed and requires dilution with water. But in rice the starch has to be converted into sugar before fermentation. It contains about 40 per cent. of pure alcohol by volume (30° under proof).

V. **Toddy.**—It is fermented juice obtained from the spadix of the fan palm, bastard date, and cocoanut. When the fresh juice is exposed to the sun for about ten hours fermentation sets in, due to the conversion of sugar, contained in the juice, into alcohol; the fermentation is the result of the multiplication of the yeast-fungus contained in the liquid, and the frothing is due to the production of carbon dioxide gas during fermentation. It contains about 5 per cent. of alcohol and resembles beer in its effects. Toddy is largely consumed by the poorer classes as a cheap intoxicating drink.

Action and Uses of Alcohol

Alcohol when taken into the stomach is freely absorbed therefore it requires no digestion. It increases the secretion and stimulates the muscular activity of the stomach. There is a consensus of opinion that alcohol when immoderately taken retards digestion and leads to degeneration of the alimentary tract. Liqueurs taken after a heavy meal give a fillip to digestion and often counteract the bad effects of tea and coffee when taken at the same time.

The absorption of alcohol is very rapid, and it is found to circulate in the blood within fifteen minutes after ingestion. If freely indulged in, it causes a permanent dilatation of the vessels of the face, especially of the nose.

Some important effects are also produced on the brain. When the cerebral vessels are dilated, intellectual activity may for the time being be so much increased that the person is enabled to perform increased intellectual work. Thackeray, for instance, got some of his best thoughts "when driving home from drinking with his skin full of wine."

The question whether alcohol is a food has been much discussed, and the chief point is whether it can be regarded as a protein sparer. Proteins contribute to the formation and repair of tissues; carbohydrates and fats are sources of heat and energy. Since alcohol does not contain any nitrogen, it cannot replace protein and therefore has no power to build tissues. Since about 90 p.c. of alcohol taken disappears in the body and is converted into CO_2 and water, alcohol by virtue of the chemical energy thus liberated can replace carbohydrates and fats in the diet, and in this sense is a non-nitrogenous food. Moreover it does not require more energy for absorption than other foods. But when taken with other foods it economises the use of fat and carbohydrate, which in their turn are stored in the body, the carbohydrate as glycogen, and fat in the tissues. As alcohol does not require digestion it is in a sense superior to other foods.

Although it cannot replace protein, alcohol will, under certain conditions, spare the protein in the same way as fat. It has been experimentally shown (Rosemann and Neumann) that on an ordinary diet the nitrogen equilibrium is maintained at a constant level, but if part of fat is withheld from the same diet, nitrogen excretion increases, showing destruction of protein, *i.e.*, proteins are being drawn upon to supply the energy required in place of fat. If, however, an amount of alcohol chemically equivalent to the omitted fat is added to the diet, nitrogen equilibrium again becomes established. It is thus evident that alcohol is able to spare protein in the same way as the fat, and can thus prevent tissue waste. Alcohol therefore may be regarded as a food in the sense that it will, when given with other foods, replace carbohydrate and fat for a short time and would supply energy and spare protein and prevent tissue waste. But the value of alcohol as a food is limited because the supply of energy is fixed and cannot be adjusted according to the needs of the body, nor can it be increased to meet sudden emergency, because it cannot be stored in the body like fat or carbohydrate as reserve.

Alcohol, therefore, may have a food value under special conditions, but should not be classed with foods, because its property of yielding energy is not its chief virtue, and is

overshadowed by other important and untoward actions, *viz*:—(1) its irritant local action; (2) its destructive action upon the body tissues; (3) its narcotic action; (4) its proneness to formation of a vicious habit (Bastedo). The habitual use of alcohol is at best a luxury and is not necessary for growth and maintenance of the body, moreover it neither promotes greater healthfulness nor in any way retards the onset of disease.

Of the different forms of alcoholic drinks, malt liquors, containing, as they do, large quantities of carbohydrates, are most nourishing. $1\frac{1}{2}$ oz. of bread contains as much carbohydrate as a pint of good ale. While a glass of milk yields about 184 Calories, the same quantity of good beer will yield 168.

It was formerly believed that alcohol increased the physical power for more work, but later observations have shown that it was not so, although in the beginning the muscular strength increased through increased circulation in the nervous system. This is soon followed by diminution of working power, so that the total amount of work done is less.

Alcohol is taken not for any stimulant effect, but after severe muscular work for its depressing effect on the nervous system which gives a feeling of comfort and well-being while forgetting fatigue. In fact observations made with ergograph have shown that muscular work is not increased but it lessens the appreciation of fatigue so that the workers think that they have done more work, or perhaps owing to this fact may do more work, not from increased capacity but from lessened appreciation of tiredness.

The question how much alcohol can be given to a person safely depends on a variety of circumstances. It is more harmful to those with sedentary habits than to those leading an active and outdoor life. Its effects also depend on the kind of beverage used. A glass of old and mature whisky is less injurious than the same quantity of raw spirit. For continuous use an ounce and a half of pure alcohol is all that can be utilised as a food in the human body daily. Roughly, $1\frac{1}{2}$ ozs. of pure alcohol equals 3 ozs. of whisky or brandy, which is equal to $1\frac{1}{2}$ pegs, or is equivalent to 7 ozs. of sherry, 15 ozs. of champagne, claret or white wine.

CONDIMENTS

The use of certain substances along with food, which though properly speaking cannot be classed as such, but which give relish to the food, is almost universal. These are food accessories, and better known as *condiments*. Pawlow has shown that palatable and appetising food before reaching the stomach excites salivary, gastric, and pancreatic secretions. Besides giving flavour and improving the appearance of the food and thereby exciting the secretion of

the digestive juices, condiments relieve flatulent distension occurring from fermentation in the intestines. Next to salt the most useful condiments are mustard, pepper, vinegar and ginger, but much difference of taste exists in the use of condiments. From long continued association certain condiments appear to serve best with certain foods, thus mustard is associated with ham, black pepper with eggs, lemon and salt with rice, and when deprived of the usual relish the food tastes insipid. Substances especially useful for this purpose are those obtained from the N. O. *Labiatæ* and *Umbelliferæ*.

The condiments commonly used are :—

Vinegar.—This is crude acetic acid and contains 3 to 4 per cent. of glacial acetic acid. Vinegar has well-known antiseptic and preservative properties, hence it is used for pickling fish, fruits and vegetables. It also softens hard muscle fibres of meat and cellulose of green vegetables. It is largely used with salads.

Mustard.—This is the powdered seed of the black and white varieties of mustard (*Sinapis nigra* and *alba*). Pure mustard contains 14 per cent. of carbohydrate, 0.66 per cent. of volatile oil and 35 per cent. of fixed oil. Although it does not greatly stimulate the gastric secretion, many persons find that it increases to a certain extent the appetite and often produces a sensation of warmth or a feeling akin to hunger. The expressed oil obtained from the seeds is extensively used in cooking by the Indians in preference to the powder. The powder from the black variety is often used for the preparation of curries, etc.

It is often adulterated with starch, or the oil may be abstracted. Cayenne pepper is often added to make the taste sharper and also to give colour.

Black pepper, cardamom, cloves, chillies, pod-pepper, coriander, anise, etc., are all used in the preparation of different articles of food to give colour, flavour or taste. Powdered and mixed together they are sold as "curry powder."

Mustard Oil.—Mustard oil, more than butter, *ghee* or fat, is extensively used in India, especially in Bengal. It enters into the dietary of most of the people, both rich and poor. In fact, it is the only source of body fat with the poor, who can ill afford to take either milk or *ghee* in their dietary. The essential oil which it contains imparts to the food a flavour not obtainable from any other oil.

Mustard oil is prepared by expression of the seeds, of which there are three varieties, the colza (*Brassica dichotoma*) the rape (*B. glauca*), and the rai (*B. junce*).

The oil is extensively adulterated with some form of mineral oil (Batch oil or Bloomless oil). Other oils and seeds usually employed as adulterants are *surguja* or niger seeds;

poppy seeds, *til* or sesame oil (*Sesamum indicum*), ground nut oil, *pakra oil* (*Schleichara trijuga*), and mohua oil (*Bassia latifolia*), etc. *Pakra* oil contains a glucoside which yields hydrocyanic acid.

Turmeric (*Curcuma longa*).—This is also used as a carminative and improves the colour of cooked materials. The fishy smell is removed when fishes are cooked after being smeared with turmeric powder.

Lemon.—The juice of fresh lemon is also much used, and acts as an antiscorbutic owing to the presence of *antiscorbutic vitamin.* Addition of lemon juice to some food, *e.g.*, rice, boiled fish, etc., not only gives a flavour but renders them more digestible, and it may be regarded as having an almost specific action in promoting gastric digestion. Preserved in salt it is used as an appetiser.

THE CALCUTTA MUNICIPAL ACT, 1923

Sale of Food and Drugs

405. (1) No person shall, without or otherwise than in conformity with the terms of a license granted by the Corporation in this behalf,—

(*a*) carry on in Calcutta, or at any municipal slaughter-house without Calcutta, the trade or business of a butcher; or

(*b*) sell or expose or hawk about for sale any four-footed animal, or any meat or fish intended for human consumption, in any place other than a municipal market or a private market.

406. (1) No person shall directly or indirectly, himself or by any other person on his behalf, sell, expose or hawk about for sale, or manufacture or store for sale, any food or drug which is adulterated or misbranded: Provided that an offence shall not be deemed to be committed under this section in the following cases, namely:—

(*a*) where any matter or ingredient not injurious to health has been added to any article of food or to any drug because the same is required for the production or preparation thereof; as an article of commerce in a state fit for carriage or consumption, and not fraudulently to increase the bulk, weight or measure of the article or to conceal the inferior quality thereof; or

(*b*) where any article of food or any drug is unavoidably mixed with some extraneous matter in the process of collection or preparation; or

(*c*) where a patent has been granted under any law for the time being in force in respect of any article of food, and the article is sold in the state required by the specification of the patent.

412. (1) No person shall sell, store for sale, expose or hawk about for sale, or keep for sale, any animal intended for human consumption which is diseased, or any food or drug intended for human consumption, or manufacture any such food or drug, which is unsound, unwholesome or unfit for human food.

(2) In any prosecution under this section the Court shall, unless and until the contrary is proved, presume that any animal, food, or drug found in the possession of a person who is in the habit of keeping animals of that class intended to be used for human consumption, or of keeping or manufacturing such food or drug for the purpose of human consumption, has been so kept or manufactured, as the case may be, for sale by such person.

INSPECTION, SEIZURE AND DESTRUCTION OF FOOD AND DRUGS

417. If the Health Officer, or any person authorised by him in this behalf, has reason to believe that any animal intended for human consumption is being slaughtered, or that the flesh of any such animal is being sold or exposed for sale, in any place or manner not duly authorized under this Act, he may, at any time by day or by night, without notice, inspect such place for the purpose of satisfying himself as to whether any provision of the Act or of any rule or by-law made under this Act, at the time in force, is being contravened thereat.

418. (1) The Corporation shall make provision for the constant and vigilant inspection of all animals, food and drugs intended for human consumption which are in course of transit or are exposed or hawked about for sale or of preparation for sale,

and shall also make similar provision for the inspection, during the process of manufacture, of any such food or drug.

419. (1) The Health Officer, or any person authorized by him in this behalf, may, at any time by day or by night, inspect and examine any animal, food or drug referred to in section 418 and any utensil or vessel used for preparing, manufacturing or containing any such food or drug.

(2) If any such animal appears to the Health Officer, or a person authorized as aforesaid to be diseased or if any such food or drug appears to him to be unsound, unwholesome, or unfit for human food or for medicine, as the case may be, or to be adulterated, or if any such utensil or vessel is of such kind or in such state as to render any food or drug prepared, manufactured, or contained therein unwholesome or unfit for human food, or for medicine, as the case may be, he may seize and carry away such animal, food, drug, utensil, or vessel, in order that the same may be dealt with as hereinafter in this chapter provided.

(3) The Health Officer, or a person authorized as aforesaid, may, instead of carrying away any animal, food, drug, utensil, or vessel seized under sub-section (2), leave the same in such safe custody as he thinks fit in order that the same may be dealt with as hereinafter in this chapter provided; and no person shall remove such animal, food, drug, utensil, or vessel from such custody or interfere or tamper with the same in any way while so detained.

THE BENGAL FOOD ADULTERATION ACT, 1919

1. In exercise of the power conferred by sub-section (3) of section 1 of the said Act, the Governor in Council is also pleased to direct that the operation of the Act shall be limited to the following articles of food :—(*a*) milk, (*b*) butter, (*c*) *ghee*, (*d*) *dahi*, (*e*) *chhana*, (*f*) wheat-flour, (*g*) *ata*, (*h*) mustard oil, and (*i*) tea.

Under this Act, the substances mentioned, respectively, against the articles of food named below are their normal constituents:—

Milk shall be the normal, clean and fresh secretion obtained by completely milking the udder of the healthy cow (or buffalo), properly fed and kept, and has a specific gravity of 1028 to 1030 at 15.50°C., and shall contain 4·4 p.c. of lactose.

Butter is the substance usually known as butter made exclusively from milk or cream or both, with or without salt or other preservative and with or without the addition of vegetable colouring matter.

Ghee is the pure clarified milk fat of the buffalo or cow or both and has a butyro-refractometer reading of not less than 40 and not more than 42·5 at 40°C.; and a Reichert-Wollny value in the case of cow ghee of not less than 24, in the case of buffalo ghee of not less than 28.

Dahi is the product obtained by lactic acid fermentation of the pure milk of cow or buffalo and shall have the same percentage of fat as the milk from which it is derived.

Chhana exposed for sale is the product obtained by precipitating

curd from boiling milk by the addition of lactic acid liquor and shall contain not less than 10 p.c. of milk fat.

Wheat-flour (maida) is the fine clean sound product made by milling wheat and bolting or dressing the resulting wheat meal, and contains not more than 1 per cent. of ash calculated on dried substance.

Ata is the coarse product obtained by milling and sieving wheat and shall contain not more than 2·5 p.c. of ash calculated on the dried substance, *i.e.*, dried to constant weight at 100°C.

Mustard oil is the fixed oil expressed or extracted from mustard seed and has a saponification value of not less than 169 and not more than 175 and an iodine value of not less than 96 and not more than 104.

Tea is the leaves and buds of various species of *Thea* prepared by the usual trade processes. It contains between 4 and 8 per cent. of total ash, the proportion of this ash soluble in boiling distilled water being not less than 40 per cent. The extract obtained by boiling one part of tea with 100 parts by weight of distilled water for one hour is not less than 30 per cent. (The tea used in determining the percentage of total ash and extract is "dry tea," that is, tea dried to constant weight at 100 degrees C.).

2. In respect of the articles of food named below, of which the normal constituents have been declared under section 4 of the Act, the deficiencies in their constituents of additions of extraneous matter or proportions of water mentioned against each article of food shall, for the purposes of the Act, raise a presumption, until the contrary is proved, that the particular article of food is not genuine or is injurious to health :—

1. *Milk*.—(*a*) Where a sample of milk contains less than 4.4 p.c. of lactose it shall be presumed, until contrary is proved, that the milk is not genuine by reason of the addition thereto of water.

(*b*) Where a sample of cow's milk contains less than 3.5 per cent. of milk fat, the milk is not genuine, by reason of the abstraction therefrom of milk fat or the addition thereto of water.

(*c*) Where a sample of buffalo's milk contains less than 6 per cent. of milk fat, it shall be presumed that the milk is not genuine for the same reason.

(*d*) Where a sample of cow's milk contains less than 8.5 per cent. of milk solids other than milk fat, it shall be presumed that the milk is not genuine, by reason of the abstraction therefrom of milk solids other than fat or the addition thereto of water.

(*e*) Where a sample of buffalo milk contains less than 9 per cent. of milk solids other than milk fat, it shall be presumed, that the milk is not genuine.

2. *Butter*.—Where the proportion of water in a sample of butter exceeds 20 per cent., it shall be presumed that the butter is not genuine, by reason of the excessive amount of water therein.

3. *Dahi*.—(*a*) Where a sample of *dahi* derived from cow's milk contains less than 3·5 p.c. of milk fat, it shall be presumed, until the contrary is proved, that the *dahi* is not genuine by reason of the abstraction therefrom of milk fat or theaddition thereto of water. (*b*) Where a sample of *dahi* derived from buffalo's milk contains less than 6 p.c. of milk fat, it shall be presumed, until the contrary is proved, that the *dahi* is not genuine by reason of the abstraction therefrom of milk fat or addition thereto of water.

4. *Chhana*.—Where a sample of *chhana* exposed for sale contains less than 10 p.c. of milk fat, it shall be presumed, until the contrary is proved, that the *chhana* is not genuine by reason of the abstraction therefrom of milk fat or the addition thereto of water.

5. *Wheat-flour*.—(*a*) Where the proportion of ash in a sample of wheat-flour (*maida*) exceeds 1 per cent., it shall be presumed that the wheat-flour is not genuine by reason of the excessive amount of extraneous mineral matter therein.

6. *Ata.*—Where the proportion of ash in a sample of *ata* exceeds 2·5 p.c. calculated on dried substance, *i.e.*, dried to constant weight at 100°C., it shall be presumed, until the contrary is proved, that the *ata* is not genuine by reason of the excessive amount of extraneous mineral matter therein.

7. *Ghee.*—(*a*) Where in any sample of ghee the butyro-refractometer reading at 40°C. is less than 40 or more than 42.5, it shall be presumed, that the ghee is not genuine by reason of the addition thereto of extraneous fat or oil.

(*b*) Where in a sample of cow's ghee, the Reichert-Wollny value is less than 24, or the saponification value is less than 220, it shall be presumed, that the ghee is not genuine, by reason of the addition thereto of extraneous fat or oil.

(*c*) Where in a sample of buffalo's ghee, Reichert-Wollny value is less than 30, or the saponification value is less than 222, it shall be presumed that the ghee is not genuine, for the same reason.

(*d*) Where in a sample of mixed cow and buffalo ghee the Reichert-Wollny value is less than 28, and the saponification value is less than 222, it shall be presumed that the ghee is not genuine.

8. *Mustard Oil.* (*a*) Where in a sample of mustard oil, the saponification value is less than 169 or more than 175, it shall be presumed that the mustard oil is not genuine by reason of the addition thereto of extraneous oil. (*b*) Where in a sample of mustard oil, the iodine value is less than 96 or more than 104, it shall be presumed, that the mustard oil is not genuine by reason of the addition thereto of extraneous oil.

9. *Tea.*—(*a*) Where the proportion of total ash (determined on dry tea, that is, tea dried to constant weight at 100° C.) is below 4 per cent. it shall be presumed that the tea is not genuine by reason of the abstraction therefrom of soluble matter; (*b*) where the proportion of total ash (determined on dry tea, that is, dried to constant weight at 100° C.) is over 8 per cent., it shall be presumed that the tea is not genuine by reason of the addition thereto of extraneous matter; (*c*) where in the total ash, as determined above the proportion of ash soluble in boiling water is less than 40 per cent., it shall be presumed that the tea is not genuine by reason of the abstraction therefrom of soluble matter; (*d*) where the extract obtained by boiling dry tea (that is, tea dried to constant weight at 100° C.) with 100 parts by weight of distilled water for one hour is less than 30 per cent., it shall be presumed that the tea is not genuine by reason of the abstraction therefrom of soluble matter; (*e*) where leaves are present not conforming in structure to those of the Camellia genus, it shall be presumed unless the contrary is proved, that the tea is not genuine by reason of the addition thereto of extraneous matter. Tea shall be derived exclusively from the leaves and buds of plants of the "Tea" species.

CHAPTER XI

DISPOSAL OF REFUSE

In every town public health largely depends on the efficiency with which all refuse is collected and removed. Refuse includes town and house refuse, and human excreta. The former are collected and removed by scavenging and consist of (1) *dry refuse*—ashes, cinders, paper, old iron, glass, tin, rag, etc.; (2) *garbage*—leaves and vegetables, potato parings, rotten fruit, kitchen waste, grease, etc.; (3) *stable litter*; (4) *street sweepings*—leaves, rags, horse and cow dung, and often human excreta. Human excreta (faeces and urine) are removed either by the hand or by mechanical means (Conservancy System), or by a system of drains and sewers to some place outside the town (Water-carriage System).

SCAVENGING

This includes the collection and removal of all town and domestic refuse and other waste material not carried by sewers, by means of manual labour.

Organic refuse has a tendency to undergo putrefactive changes in the presence of warmth and moisture, when it

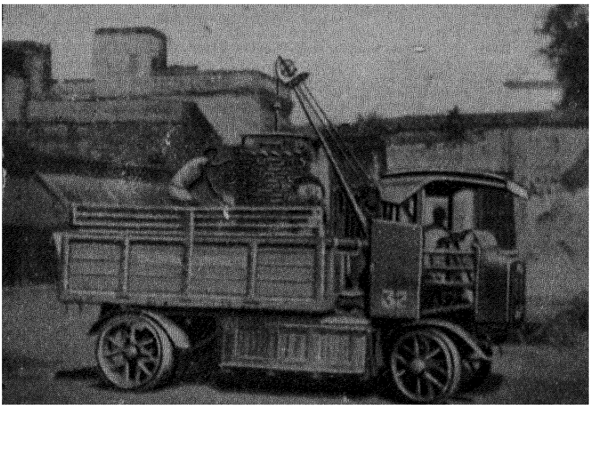

FIG. 31.—Conservancy Lorry for Removal of Street Refuse.

gives off an offensive smell and serves as a breeding place for flies, and provides food for rats, vermin, etc.; hence the necessity for its early removal. The refuse is received either in ashpits or dustbins, as its deposit on the roadside is

objectionable since it is liable to be carried about by the wind or washed out of the heap during rains.

Dustbins are best made with corrugated iron. They should not be too large; the simplest shape being a circular one open at both ends, provided with a pair of handles. They should be placed on a raised, concreted and cemented surface, always at a fair distance from any dwelling-house, and provided with a cover. In India owing to the climatic conditions and the rains refuse decomposes very rapidly, and flies and vermin multiply enormously. It is, therefore, necessary that the contents of the dustbins, should be removed daily, or twice a day, by especially constructed carts. These carts are generally drawn by bullocks horses or buffaloes. Motor vans, which can be tilted by a mechanical arrangement, are used in big cities for the collection of street refuse from the dust bins. All these refuse carts should be covered to prevent nuisance when passing along roads fully loaded. The collection should be carried out during the early hours of the morning to minimise the nuisance. The refuse should be kept dry as far as possible.

Wheelbarrows are small hand-driven carts used to collect refuse from narrow lanes and bye-lanes where refuse carts drawn by bullocks and horses cannot go. The refuse collected by wheelbarrows is deposited in dustbins.

Disposal of Refuse.—After collection the refuse must be disposed of in such a manner as will not create any nuisance. Several methods are in vogue in India, *viz.* (*a*) dumping and filling; (*b*) disposal in the sea (possible only in sea coast towns); and (*c*) incineration or burning. The choice of the system to be adopted is generally determined by the local conditions and the funds available.

FIG. 32.—WHEELBARROW.

1. *Dumping.* In this method the refuse is generally utilised in filling up insanitary tanks, or reclaiming low lying

lands. But since it creates a great nuisance to the neighbourhood by the production of offensive gas, breeding of flies, harbouring rats and other vermin, it is necessary that the land selected should be as far away from human habitation as possible, or outside the limits of the town. The work of filling up tanks with refuse should not be done during the rains, as foul liquid draining from the heap may cause serious pollution of the nearest water supply. (*See* Made Soil, p. 121).

Dumping is an old method and modern science has shown that the breaking down of lignins and celluloses is due to the action of fungi and various aerobic bacteria, but to be effective these organisms require an adequate amount of combined nitrogen and phosphate and an alkaline reaction. To supply this want a preparation under the name of "Adco" has been devised which hastens the formation of *humus* or "*compost*" from vegetable waste. In India where cow dung and cow's urine are easily available they supply the requisite nitrogen, etc., for the formation of humus. Experiments carried out at Mysore and Indore by Meildazis, Jackson and Wad (*Indian Medical Gazette, Feb.* 1934) give a new orientation to the disposal of garbage and night-soil, where a large amount of compost has been prepared from these wastes. If this can be done without much offence, and the product could be utilized for fertilization, a great problem for the disposal of night-soil at a profit will be solved. The experiments carried out and the experience gained with the original experimental heaps show that street refuse can be composted into a valuable organic manure without fly breeding when a properly emulsified night-soil solution is prepared. The following procedure has been recommended by Meildazis :

1. Place the rubbish in piles 6 feet wide at the base, 2 feet high and 4 feet wide at the top. Separate all glass, tins, earthenware pots, stones, etc.
2. Trench the pile down the centre for the application of the night-soil emulsion.
3. Prepare a uniform emulsion of one part night-soil to four parts liquid, carefully excluding all leaves and other extraneous matter.
4. Apply the emulsion to the trenched rubbish piles at the rate of two gallons per running foot. Close the trench in the pile.
5. Apply the emulsion to the rubbish piles daily for a period of about two weeks or until the pile becomes fairly moist. Then make applications to the pile every third day. The interval of application will depend upon the weather conditions. When rains are fairly heavy, the strength of the emulsion may be increased and the rate of application decreased. If the rains are continuous and heavy enough to soak the piles thoroughly, some shelter must be provided in

order to maintain the high temperatures necessary for composting.

6. When the rubbish has broken down into a brown humus mass one-half of the pile may be removed and stored for screening; the remaining portion of the pile may then be mixed with raw rubbish and the process repeated as from the beginning.

In communities where the night-soil is collected free of extraneous matter, composting may safely be carried out by the above method without fly breeding. In order to ensure a uniform emulsion, the night-soil may be mixed with the proper proportion of water and allowed to liquefy before application to the piles. This liquefaction will reduce the solid lumps of night-soil which would require additional time to break down in the rubbish pile.

In Calcutta the refuse is taken to the unloading platforms whence it is carried by railway trucks and utilised in reclaiming low-lying lands.

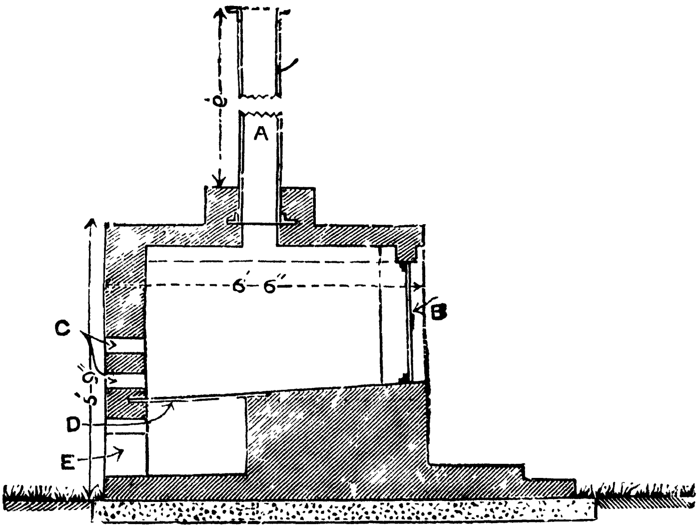

FIG. 33 INCINERATOR. Longitudinal section.
A, Chimney. B, Charging door. C, Openings for stoking.
D, Iron grating. E, Opening for removing ashes.

2. *Incineration.*—The best method of disposal of refuse is to render the same harmless by burning. This is generally done in a "Destructor Furnace" or "Incinerator." By this process the refuse is reduced to about one-fourth of its original weight, and the organic matter is transformed into innocuous vapours—carbon dioxide and nitrogen. The residuum left after the combustion is a mass of hard material called "clinkers," which are usually utilised for road-making; powdered and mixed with lime, they form cement.

In case of a big town it would be more convenient to have it divided into districts, and each one provided with a destructor furnace, which may be placed in a central position to minimise the expense of transport.

During the last war quite a large number of incinerators were used, but as far as the general principles are concerned most of them are practically the same, and are modified to meet the local conditions. All incinerators have the following features in common :—

1. A furnace or combustion chamber lined with brick.

2. A suitable arrangement with a platform for tipping the refuse through a series of feeding holes through which the refuse falls into the cells below.

3. After the refuse has been brought together by the stokers it is burnt down to one-third to one-fourth of its original weight.

4. A baffle plate so placed that all fumes are driven through the hottest part of the incinerator or combustion chamber before passing up the chimney.

Both the Meldrum and Horsfall destructors were used during the war with considerable success. Large scale destructors like the Horsfall can only operate if forced draught is available by blowers. But no scheme of refuse destructor has yet been devised that will pay for itself. The Meldrum destructor depends for its action upon a forced draught produced by a steam jet. When properly used it acts very satisfactorily, but needs great care for successful and continuous work (*see* Fig. 44). The fumes are cremated by passing through a combustion chamber which separates the furnace from the flue. For a large type it is necessary to feed from a platform at the top, the material passing directly on to the fire.

The incinerators built of mud or iron without fire brick do not give satisfactory results. They are, however, suitable for fairs and melahs of short duration. The "Beehive Incinerator" which was extensively used during the war will be found to give very satisfactory result under such conditions (*see* Village Sanitation). A common defect in many incinerators is that the draught is not sufficient, consequently they give off offensive smoke which creates a nuisance.

CHAPTER XII

DISPOSAL OF HUMAN EXCRETA

It is of primary importance in any community of persons to make arrangements for the collection and removal of excreta ; and on the efficiency with which these are removed depends the health of the people inasmuch as many organisms, chiefly those of cholera, typhoid and dysentery, find their way from the fæcal matter into the gut of the healthy human beings. In Western countries, where the water-carriage system is used for the removal and disposal of human excreta, most of these diseases so common in tropical countries have almost disappeared.

In many of the tropical countries there are no organised arrangements for the collection and disposal of human excreta. Indeed in most villages and non-municipal areas there are no arrangements for latrines with the result that people use any open land for defæcation. In certain parts of India (United Provinces) the open terrace of the house is often used for the purpose and the excretal matter is left to dry under the heat of the sun. It is possible that the desiccating effect of the tropical sun may render any specific organism harmless, but there is always the possibility of these being washed by the rain into the nearest tank, river or well, or being carried about by flies, etc., and infecting food. Apart from the sanitary point the idea of fæcal matter being deposited indiscriminately in and around the house and the absence of any privacy when the open field is used, is revolting to all ideas of decency.

CONSERVANCY SYSTEM

In small municipal towns for want of sufficient funds it is not possible to lay down sewers for the removal of excreta, and since they cannot be allowed to accumulate about the house, arrangements should be made for their removal from privies and latrines by the dry method.

The efficient working of this system is of great importance ; the principle aimed at being that filth, refuse and all putrescible matter should not be exposed to flies, or allowed to contaminate the water, but should be transported and disposed of safely and with creation of the least nuisance possible.

The amount of excreta to be removed daily depends upon the number and the habits of the people. An adult European male living on a mixed diet passes about four

ounces of solid and fifty ounces of liquid excreta daily, while an Indian, owing to his vegetarian diet, passes between eight to sixteen ounces of solid. Taking all ages and both sexes, the average daily amount of solid excreta per head is about twelve ounces. In India water, instead of paper, is used for cleansing purposes, and this ablution water together with the liquid excreta make up about eighty ounces. The average daily excreta to be dealt with in a mixed population can be estimated by multiplying twelve ounces of solid and eighty of liquid by the number of persons.

The important constituents of excreta are nitrogen, phosphates and potash. Fæcal matter, specially when mixed with urine, undergoes rapid decomposition and gives rise to foul gases, chiefly organic vapours and ammonium sulphide. It is a matter of practical importance that the excreta should be protected from rain and flood water, else not only will the sewage be not efficiently removed, but the whole mass will undergo fermentation and create a serious nuisance.

Latrines.—In villages people generally use the garden or some open land for purposes of nature. This is a very insanitary practice, as fæces charged with pathogenic organisms or their spores are liable to be conveyed by dirty hands or feet, or by the agency of flies, into the human system. Furthermore, after rains, the washings often pollute tanks or any source of water-supply near about and help in the spread of water-borne diseases. It is therefore necessary that some arrangement in the shape of latrines or privies should be made to overcome these defects.

For practical purposes an arbitrary distinction is made between a *latrine* and a *privy*. A privy for public use is a latrine. Certain cardinal rules have to be observed in the construction of latrines. They should always be placed on an impermeable base which should be higher than the surrounding ground. They should be so constructed that the sun's rays can enter the latrine apartment for as many hours in the day as possible, that rain is kept out, and that privacy is maintained. The following details in their construction require careful attention:—

1. They should be so designed that all excreta and wash water will automatically find their way into some receptacle, so that no brushing will be necessary.

2. The materials used should be non-absorbent to prevent pollution of the soil through soakage.

3. Satisfactory arrangements for the reception of night-soil, and separation of liquid excreta, should be made (*see* Fig. 34).

4. They should be provided with a separate passage for the sweeper leading to the trap door.

5. Ventilation should be thorough and efficient, even when the doors are closed.

A **model latrine** or **privy** may be described under the following heads :—

1. The superstructure, which includes the roof and the walls.
2. The floor and the seat.
3. The collecting chamber.

1. *The Roof.*—The roof may be either terraced or sloping. Sloping roofs may be of corrugated iron, tiles or grass.

The *walls* may be either of brickwork, corrugated iron or bamboo matting. They should be pigeon-holed towards the upper half for proper ventilation. It is better that the roof should have an ample ridge ventilation ; or an opening of about two feet may be left between the wall and the roof (*see* figure 34). Large ventilating holes, each two feet square, may also serve the same purpose.

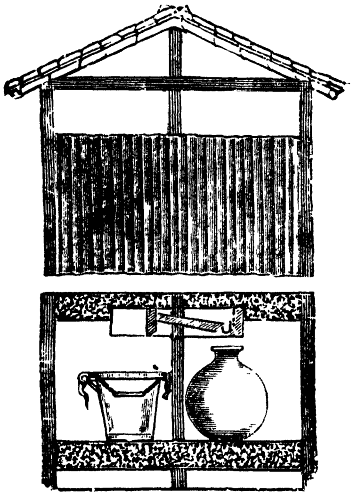

FIG. 34.—PRIVATE LATRINE

Showing the superstructure, the walls, the collecting chamber with antisplash pail, and a vessel for collection of urine and water.

2. *The Floor and the Seat.*—The *floor* should be made of some impervious material, *e.g.*, brickwork set in cement, slate, stone or iron, and should be sloped towards an opening or drain leading to a receptacle. The best material is either vitrified brick, marble, or granolithic cement. These are non-absorbent, and when properly laid make an elegant floor which can be easily cleaned, and require no further attention.

The *Foot Rests* must be in the right position and not too wide apart, or else the fæces will not fall into the receptacle below. The sides of the opening should be sloped from above downwards and outwards, this will do away with the disadvantage of fouling the sides.

3. *The Collecting Chamber* should always be of masonry work with the walls and floors cemented and corners rounded off to facilitate easy and thorough cleansing. The floors should be concreted and raised 6 in. above the level of the surrounding ground with a slope leading to an opening. The trap-door should be well-fitting and properly tarred.

The *Pail* or receptacle should be placed about 6 inches under the seat to prevent splashing. In some cases this distance is very great and may be 8 ft. to 10 ft. even more. The best receptacle is a tarred iron or galvanised bucket provided with a movable lid or cover. An earthenware vessel (*gumla*) is however ordinarily used. These should be

periodically taken out, washed, and tarred. To prevent splashing special antisplash pails of galvanised iron with a removable conical cover (*see* figure 34) may be used. These can be fitted with a cover and carried directly to the trenching ground, and will do away with the use of soil carts.

The practice of using water for cleansing purposes in India necessitates a separate arrangement. The urine and ablution water are carried by a separate conduit or pipe and collected into a special receptacle placed at a convenient site in the collecting chamber, while the solid excreta fall directly on the bucket. The receptacle for the urine and ablution water may be a tarred earthenware or an iron vessel. This separation system has many advantages. The liquid being collected in a separate receptacle decomposition does not take place so rapidly and, therefore, the latrine becomes less offensive, there is also less nuisance during removal. Apart from these advantages, the separation system prevents the possibility of splashing and overflowing of the pails, which so often happens when used by a large family. To avoid splashing people often use any part of the latrine other than over the proper opening and thus make it horribly filthy. Therefore especially designed platforms and foot rests must be constructed to separate the urine and ablution water. The platform may be made of glazed stoneware, brick-work plastered with cement, or of cast iron.

Service privies should be at least 6 feet away from any dwelling to permit a free circulation of air between the house and the privies. From a well or a tank they should be at a distance of at least 50 feet. The pail contents should as far as possible be kept dry by throwing ash, sand, or dry powdered earth into the pail after each visit. This has the advantage of lessening the emanations of foul gases. The contents of the pail should be removed at least once a day.

Besides the above the following are also used :—

1. The Well or Pit Latrine.
2. Bored-hole Latrine.
3. The open-air privy in fields.
4. The Commode.
5. The Receptacle Latrine.
6. The Trench Latrines.

1. The Well or Pit Latrine.—*In this system there is no* movable receptacle, but the excreta are received in a hole or well, usually 6 ft. to 20 ft. deep, sunk in the ground. This system is most insanitary as not only foul gases are evolved, but there is risk of pollution of water-supply through soakage, especially after a rise in the level of the sub-soil water. But it is less dangerous than surface pollution caused by indiscriminate defæcation where there is no organised conservancy or privy arrangement. A modified form of well-

privy is now largely used in the form of "Pit Latrines." By this system, provided the site and soil are favourable, the effect is more or less automatic. The excreta are finally and quickly disposed of, thereby rendering any further handling unnecessary, which makes the ordinary pail latrine so objectionable. These were largely used in France during the war.

(*a*) *The Site.*—It should be on an elevated land and well away from and below the water supply, so that the flow of ground water is away from this supply. The soil should be porous and the pit should be unlined. A clay soil or a soil subject to frequent flooding, is unsuitable. Disinfectants by killing the bacteria stop the nitrifying process.

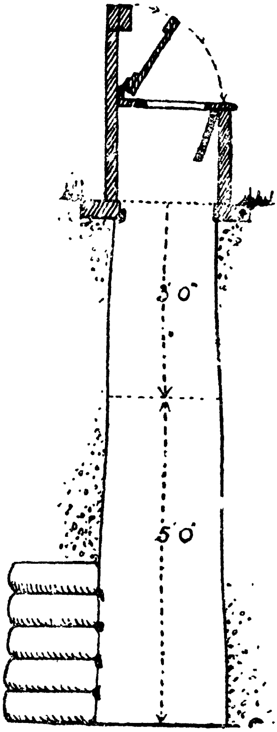

FIG. 35.—PIT LATRINE (From History of the Great War).

(*b*) *Depth.*—This will depend upon the location of the site and the nature of the soil. Ordinarily 6 to 8 ft. is enough. The number of bacteria diminishes below this depth.

(*c*) *Seat.*—It is better, whenever possible, to have the seat made of wood or sandstone. The wood should be antproof and tarred or creosoted all over, and should rest on a layer of bricks to make it higher than the adjoining ground.

(*d*) *Drainage.*—It is essential that a well constructed drain surrounding the whole building to carry the rain and storm water should be provided for.

2. **Bored-hole Latrines.**—These were devised with the object of supplying cheap latrines in rural areas to reduce the incidence and disease resulting from want of latrine accommodation. They have been used successfully in Ceylon, Java, Federated Malay State, Madras and United Provinces, and provide a satisfactory and inexpensive method of disposal of human excreta. They are cheap and require very little space.

They resemble pit latrines and consist of a circular hole 14 in. to 16 in. in diameter and 10 ft. to 20 ft. deep. They are most successful if the hole goes at least three feet below the surface of the ground water. The top of the hole is covered by the squatting plate of reinforced concrete 30 in. $\times$36 in.$\times 2\frac{1}{2}$ in. with a slope to a hole 10 in.$\times$6 in. at the centre (*see* Fig. 36). The superstructure may be built

according to the taste and local conditions to afford privacy and protection from sun and rain. When they fill up to about $2\frac{1}{2}$ feet from the ground level they should be filled in with dry earth and the squatting plate may be removed and placed over fresh borings. As in the case of pit latrines, the excreta undergo biological disintegration and liquefaction with formation of gases. These latrines as also the trench latrines (*see* page 243) may be used with much benefit for a considerable period where there is no organised conservancy system, *e.g.*, in tea gardens, and other congregations of labour.

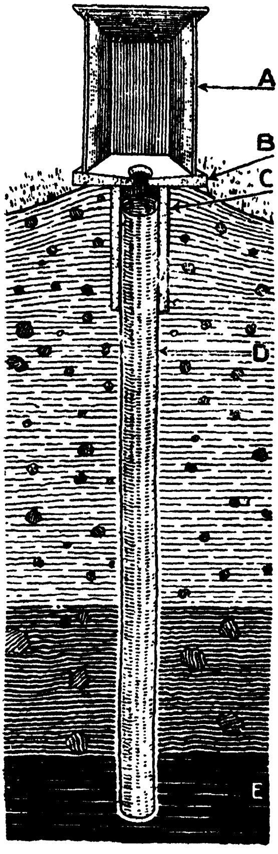

FIG. 36.—BORED-HOLE LATRINE.
A, Superstructure; B, Squatting plate; C, Concrete cylinder, usually not necessary; D, Bamboo basket for retaining soft earth; E. Water. (Tropical Diseases Bulletin, vol 26, No. 12.)

They should be bored in the earth which is moderately hard and compact and the site selected should be 50 ft. away from any well or tank, and not subject to flooding. A lining of basket work made of split bamboo is useful in preventing caving. Where the surface soil is soft an empty barrel of 18 in. or cement cylinder will support the walls of the hole at the top. Breeding of flies takes place up to 9 ft. from the surface, but a spray of crude oil 4 parts and kerosene 1 part will stop this menace. These latrines are extensively used at the naval base now under construction at Singapore and last about six weeks. They are closed when the night-soil is 7 ft. from the surface. After the night-soil has disintegrated and disappeared, which takes about two months, they can be used again.

3. The Open-air Privy in the Field.—In villages and rural areas where no proper arrangement for disposal of night-soil exists, people usually go to some open field or waste land to empty their bowels and then use a tank or any source of water available for ablution purposes. Such a practice should be discouraged as it is not only very insanitary but also the chief factor in spreading hook-worm infection and water-borne diseases.

4. **The Commode.**—The use of the commode is very popular with the Europeans in India. The arrangement is very simple and consists of a porcelain or enamelled pan fitted in a wooden or iron stand, the top of which forms the seat. If proper care is taken to keep the pan clean there can be no objection to its use.

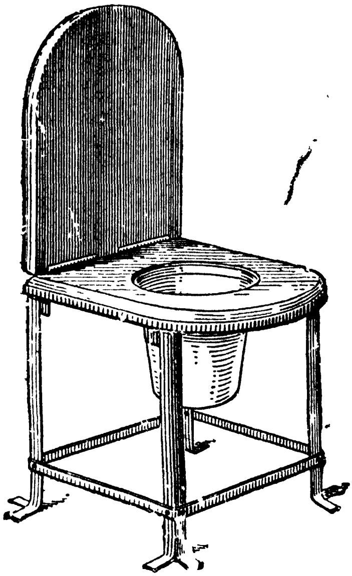

FIG. 37.—THE COMMODE.

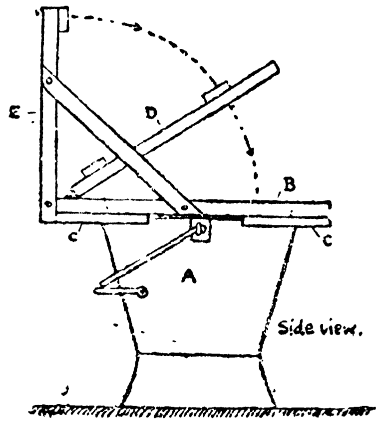

FIG. 38.—FLY-PROOF RECEPTACLE LATRINE.

A, Latrine bucket. B, Seat. C Cleats to ensure proper position. D, Fly-proof cover. E, Back standard causing cover to close automatically. (From History of the Great War).

5. **The Receptacle Latrine.**—This form of latrine was extensively used during the war with much success. It consists of a wooden seat fixed directly on the latrine bucket. The seat is fitted with a self-closing lid which makes it fly-proof. The individual pails can be removed directly either into the trenching ground or for incineration; or the contents may be transferred into one large receptacle for removal. This receptacle latrine may be conveniently placed in the bath room, and provided proper care is taken to keep it clean and periodically disinfected it will be found very satisfactory in the moffusil stations.

6. **The Trench Latrines.**—These are made by digging long trenches usually 1 to 2 feet deep and 8 to 10 inches wide. The person using it should place one foot on each side of the trench and squat in such a manner that the urine, ablution water and the solid excreta should fall directly into the trench. They should be properly screened and after use should be filled up with the excavated earth. These latrines are satisfactory as a temporary arrangement during

fairs (which see), etc., or in rural areas where there is no organised conservancy system.

Public Latrines and Urinals

There are two types of public latrines:—

1. Fixed or Permanent.
2. Movable or Temporary.

1. Fixed or Permanent Latrines.—In most towns and villages, latrines and urinals for the use of the public in railway stations, schools, theatres and other public places

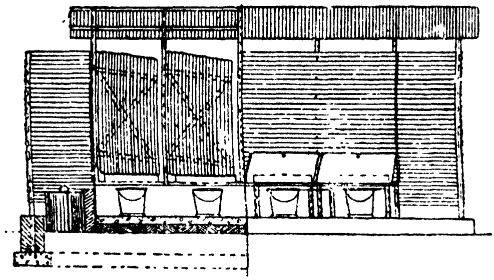

Fig. 39.—Four-seated Public Latrine
Half Section and Elevation

should be arranged for. In places provided with a water-carriage system these do not give any difficulty, and there will be no nuisance if arrangements are made for their proper flushing, ventilation and lighting. But it is not so easy where there are no sewers and where the excreta have to be removed by sweepers or *methers*. Unless these are properly constructed and attended to, they are a great nuisance. In order to minimise this the following points require careful attention:—

1. They must be well lighted and ventilated, and privacy must be maintained.
2. The urine and wash water must be separated from the solid excreta.

All public latrines should be constructed on a masonry plinth 6 inches to 1 foot high. The superstructure may be of angle iron framing with corrugated screens and roof, so arranged that there is a free circulation of air throughout. Instead of corrugated iron the superstructure may be built with bricks and cement, and provided the walls are cement plastered or covered with glazed tiles to prevent soakage, these will be found to be quite satisfactory. The floor should be of cement or patent stone, so that the latrine can be effectively washed and kept clean.

The separation of wash water and urine from solid excreta is necessary to minimise nuisance. This requires suitable

seat arrangements, so that the solid excreta will be deposited in separate receptacles, while the urine and wash water will be drained into a special vessel or into a masonry cesspit. The best form of seat is that of Donaldson's separation system (*see* fig. 41). The shaded portion of the foot rests are used during defæcation when the night-soil falls into special buckets; during washing the user moves forward and the wash water is conveyed through a different opening into a common channel connecting a row of seats and is collected in a separate receptacle. Masonry seats are better than iron ones as the former can be easily cleaned, while the latter require to be tarred periodically and cannot be kept so clean. With regard to all public latrines the following points must be carefully observed:—

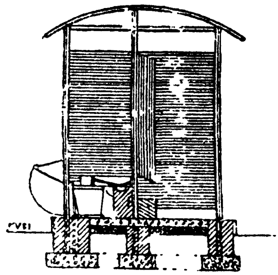

FIG. 40.—CROSS-SECTION OF PUBLIC LATRINE.

1. No wood or any absorbent material should enter into their construction.
2. They should be thoroughly ventilated and kept scrupulously clean.
3. The approaches should be properly made and kept clean. A sweeper should be retained for each latrine and provided with a suitable disinfectant, *e.g.* crude oil.
4. Every latrine should be provided with a light and an ample supply of water.
5. The receptacles for the night-soil and wash water should be so placed as to be easily removed and cleaned.
6. There should be provision for the removal of the solid and liquid excreta in air-tight receptacles.
7. The night-soil receptacles should be daily washed and periodically tarred.

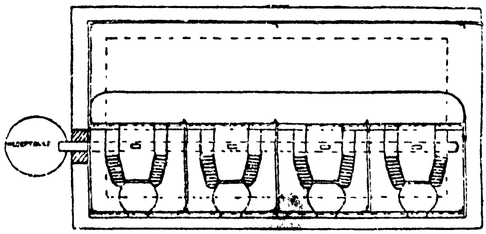

FIG. 41.—SEAT ARRANGEMENT IN A PUBLIC LATRINE. Note the separation system.

It is almost impossible to keep a public latrine clean and avoid creating a nuisance. They are always misused. The only way to avoid this is to see that the latrines are regularly

and efficiently cleansed. The sweeper must be in constant attendance, otherwise people will use any part of the latrine especially the passage and create a nuisance.

A large number of smaller latrines suitably distributed is more effective than a few large ones which are much more costly to construct and maintain.

2. Movable or Temporary Latrines.—These are of great use in segregation camps, *melahs* (fairs), and all other places where latrines are required only temporarily. They are common in dry parts of India. The latrine should be easy of transport, and when not in use so compact that it can be packed away in a godown or shed. The receptacle for night-soil is simply placed on the ground with bricks for foot rests. They require no plinth or roof, and the partitions are made with corrugated iron sheeting. They are removed when the ground becomes foul and ill-smelling, when it should be dug up and left exposed to the sun and air for about a year. No masonry work should enter into their construction, and the site should always be high. The latrines should be removed once in a month during the rains and every second month during the dry season.

Urinals.—Like latrines arrangements should be made for urinals at convenient places. Where there is a water-carriage system these give no trouble, provided they are properly constructed, well-flushed and kept clean. The superstructure and partitions may be of corrugated iron, but a masonry structure is cleaner. All surfaces with which the urine comes in contact must be smooth and non-absorbent; the best material being plate glass, glazed stoneware or slate. There should be a continuous flow of water or an automatic flush of water at short intervals. In villages the whole structure should be raised on a plinth and the urine received in a receptacle which should be emptied at regular intervals and its contents suitably disposed of.

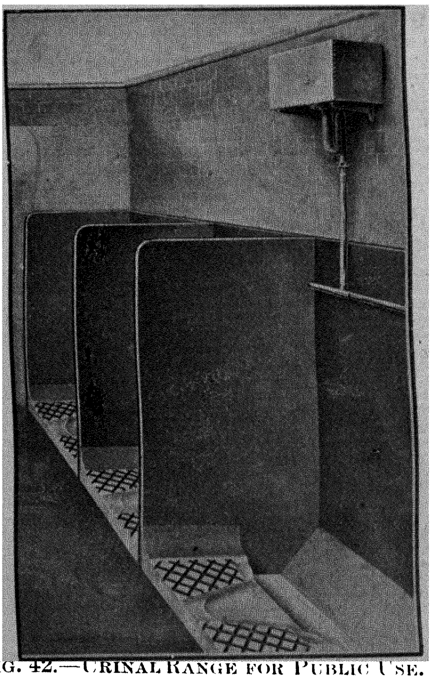

FIG. 42.—URINAL RANGE FOR PUBLIC USE.

Collection of Night-soil

The collection of night-soil is usually done by sweepers *(methers)* who remove the contents of the privy pans into tarred wooden buckets (pails) which are carried either direct to the trenching-ground, or their contents transferred into night-soil carts at the depots, and then taken to the trenching ground for final disposal. In the outskirts of Calcutta, where a hand removal system still exists, the night-soil is carried to depots and emptied into the main sewer. The collection of night-soil should be done in the early hours of the morning, and if possible once again in the afternoon. Urine and wash water should also be removed by night-soil carts for disposal. In some of the rural areas of Malay States the night-soil is disposed of in large well-like excavations, and the manure is subsequently used for agricultural purposes.

Considering the fact that nuisance increases with the bulk of the population and with the number of handlings, tis always better, whenever possible, to remove night-soil by substituting special metal receptacles in place of *gumlas*, which can be carried bodily to the trenching-ground either by a sling, or on a especially constructed "Receptacle Cart." This will have the effect of minimising nuisance by doing away with the ordinary night-soil carts, removing the filth direct from the latrines in absolutely air-tight sealed receptacles without being moved or stirred and avoiding spillage or the spread of offensive odours. This arrangement is suitable for small communities.

In Kuala Lampur and Ipoh the night-soil is carried in lorries containing 80 to 100 buckets. Two lots of buckets, red and white are used. The lorries start with clean

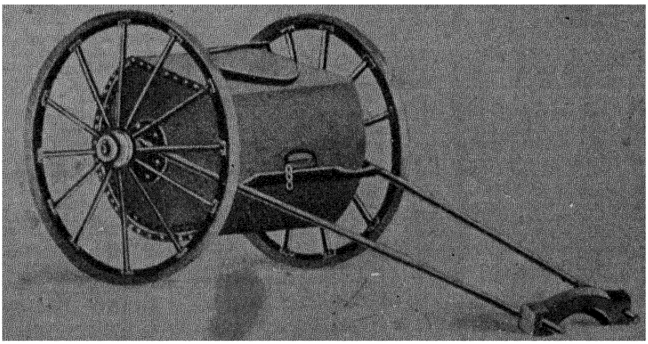

Fig. 43.—Night-soil Cart.

buckets of one colour and change these for buckets with night-soil at the latrines. .These are taken to the bucket

washing station. Most of the buckets being only one-third full they are emptied to make a complement of full buckets at the washing station and then removed to the trenching ground, washed, emptied, brought back and washed.

Night-soil Carts.—These are usually made of steel with iron wheels. They have a capacity to hold 90 to 110 gallons, and are fitted with a double lid which can be sealed with a little earth. The body is pear-shaped and is so hung that it empties itself by revolving on the axle.

Night-soil Dumping Depots.—In the outskirts of Calcutta where the hand removal system still exists and in places where there is a skeleton system of sewers, the contents of the service privies are taken into *night-soil depots* and then discharged into the sewer. This method is not an ideal method, but in the absence of the water-carriage system it is a great improvement on the alternative method of disposal of night-soil by trenching. These depots should be situated at a convenient distance so that the contents may be carried by sweepers direct thither.

Disposal of Night-soil

The disposal of night-soil in such a manner as to secure it from being any longer a nuisance or menace to public health is a difficult problem. But all excremental matters can safely be disposed of either (1) by *trenching*; (2) by complete burning (*incineration*); or (3) by *water-carriage system* at dumping depots. Trenching may be done *in situ* as in the case of shallow trench latrines or deep pit latrines; or night-soil may be removed to a distance and utilised for agricultural purposes by the formation of humus or compost (see p. 234). Burning is done in some special form of incinerators.

I. **A trenching ground** is a plot of land where the night-soil is disposed of by burying it in the soil. Strictly speaking trenching of night-soil is a biological process, but it is not included in the same category as septic tanks. Trenching plays a very important part in the disposal of sewage in the tropics, and it is important that the best method of laying out the ground and managing these places should be clearly understood.

The trenching ground should always be situated outside a town and at least a quarter of a mile away from the nearest dwelling house. It should be on a raised ground so that it will not be water-logged during the rains. Whenever possible the ground should be on one side of the town away from the prevailing wind and should be separated from the town by some rapidly growing trees, or a clump of bamboos.

The Soil.—The character of the soil is of great importance. It should be light and porous; a clay soil is unsatisfactory. Light sandy loam, occasionally found on the banks of large

rivers is very satisfactory. The nitrifying organisms which are more nu nerous in the upper layers of the soil convert the organic nitrogen in the excreta into nitrates. It is therefore necessary that the excreta should be deposited as near the surface as is safe from a sanitary point of view. Black cotton soil makes excellent ground as long as it is dry. But when it gets sticky it is not so suitable.

Method of Laying out Trenching Ground.—A trenching ground should be of sufficient size to allow of trenching of the excreta of the total population for three years, without using any part of the land twice. It should be divided into three plots, so that every plot may be trenched once every three years, the remaining two plots being kept under cultivation while the other is being used. Cultivation is of vital importance to the success of the trenching ground, for otherwise the ground becomes sewage sick and unfit for re-trenching. Col. Fry and Dr. Das have, however, shown that a trenching ground after prolonged use 'ripens' like a septic tank and can disintegrate night-soil more rapidly. In the Cossipore ground a trench opened after one month showed no trace of fæcal matter, which was all converted into black soil fit for cultivation.

The trenches should be 18 inches broad, and 12 or 18 inches deep and 20 to 30 feet long. They should be two feet apart, and should not be too long, as that will necessitate filling the trenches from two or three different points. In the dry weather night-soil to the depth of 6 inches should be put in trenches 18 inches deep; and 4 inches in trenches 12 inches deep. In wet weather 4½ inches in 18 inch and 3 inches in 12 inch trenches should be similarly filled. These then should be covered with the excavated earth. If more night-soil than mentioned above is placed in the trenches, the night-soil swells up and comes to the surface of the ground causing great nuisance. Very shallow trenching, *i.e.*, when night-soil is placed in trenches only six inches deep, is very insanitary, as with the drying action of the sun and hot winds a very highly infective dust is formed. It may, however, be done under proper supervision and where there is abundant supply of water.

The following points should be observed in the management of a trenching ground:—

1. There should be one or two good roads according to the size of the plot, within the ground, so that the carts can come right up to the trenches.

2. It should be provided either with a well or a tank for washing the buckets and carts and for irrigating the land under cultivation.

3. Arrangements should be made for draining of rain water.

4. Trench-filling should be systematic and should begin from one end of the ground

5. As soon as the carts have discharged their load into the trenches, the excreta should be immediately covered with earth which should be broken up, otherwise the ground will be a great source of nuisance and will breed flies.

6. In filling up the trenches an excess of earth should be used to form a dome, and not flush with the surface. This will allow a certain amount of sinkage due to settling of the earth, without forming a hollow or depression where water can collect.

7. There should be a covered shed for the storage of utensils, etc.

8. The carts and pails should be thoroughly cleansed both inside and out with some liquid disinfectant. Crude oil is best.

9. Cultivation should begin three months after trenching. The ground should be deep-hoed, ploughed up and sown at first with *dhoop* grass, sugar-cane or tobacco. After this all kinds of vegetables may be grown.

Disadvantages of trenching grounds :—

1. Proper supervision of the working of the trenching ground is very difficult.

2. The most common defect is that the trenches are filled too much with night-soil. These are filled to the brim with night-soil and urine and covered over only with a little earth scraped over the top so that the earth sinks to the bottom of the trenches leaving the foul smelling pool of night-soil full of maggots on the top.

3. Suitable soil is not always available, and in many parts it is difficult to get a good supply of water, which means that the carts and buckets cannot be properly washed, and the land cannot be properly cultivated.

4. Theoretically speaking a well managed ground should not breed flies, but in actual practice it does breed flies and is therefore dangerous to public health. Flies really breed in the latrines and the eggs are carried to the trenches with the night-soil where they develop into maggots. To keep away maggots and flies from the trenching grounds implies clean latrines. This can be done by not allowing the fæcal matter to remain long in the buckets and by using plenty of crude oil.

5. The larger the amount of night-soil to be disposed of, the greater is the possibility of nuisance, and the more are the defects in the system noticeable.

II. Incineration of Night-soil.—This method of disposal by completely burning up of night-soil is being greatly advocated in India. If properly carried out in a well-designed furnace destructor it will be found to be very sanitary ; and the possibility of contaminating the water-supply or the danger of polluting the air by smoke or vapour will be reduced to a minimum.

The incineration of night-soil may or may not be combined with the incineration of street refuse. In some places

a certain amount of refuse may be utilised as fuel, but this is not always so. Where the street refuse contains dry

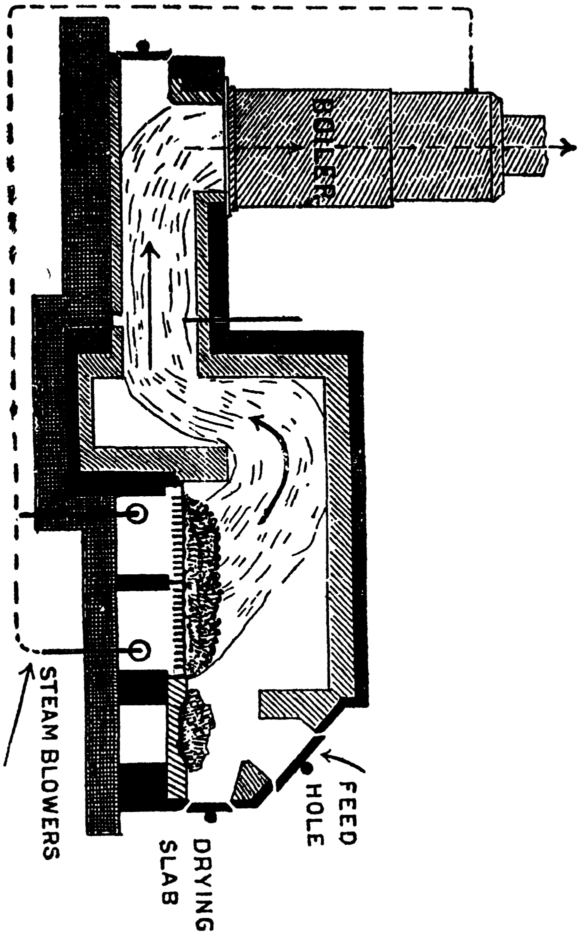

Fig. 44.—Meldrum Incinerator
(From History of the Great War)

grass, straw, rags, paper and other inoffensive combustible material, these may furnish all the fuel necessary. It is not always that one gets in Indian towns enough combustible material in the refuse to utilise for incineration of night-soil without any addition of extra fuel. This naturally makes incineration an expensive process.

The incinerators for night-soil should be of a closed type; their main principles have already been discussed (*see* p. 235), but incineration to be successful the following conditions are necessary:—

1. The incinerator must be so built as will stand rough usage and the materials used should stand extreme heat.

2. Since a good draught is essential, the air inlets must be adequate, and the chimney sufficiently large and high. The openings of the grating should not be more than $1\frac{1}{2}$ to 2 inches.

3. The smoke should be rendered inodorous either by providing a baffle plate or by placing a horizontal grid a little below the entry into the flue. This will allow the gas to pass through a layer of glowing fuel from a fire lighted on this grate.

4. The mixing up of the night-soil with the combustible material should be done in proper proportion. The fuel should be dry and the mixture should be put in the fire when it is blazing. The stokers should be well trained.

5. As mentioned before, the ordinary street refuse is not always inflammable and may not serve as a fuel, and a good supply of combustible material is, therefore, necessary. Usually saw dust, coal dust, wood shavings, dry grass or straw, are used for the purpose. It must be noted that the possibility of smoke nuisance is less if plenty of fuel is mixed with the night-soil.

6. As it is essential that the fuel should be dry, a covered shed for the storage of fuel must be provided. During the rains it is impossible to keep any combustible material in a readily inflammable condition. The mixing platform should have a concrete floor.

Disadvantages of the Hand Removal System :—

1. From a financial point of view it is not economical, as it necessitates the employment of a large number of sweepers, carts, bullocks, etc.

2. Its success depends absolutely on the way in which the work is carried out. The sweepers are very difficult to manage, and a badly worked system is a source of great danger and nuisance.

3. The wear and tear of night-soil carts, pails, etc., are very great.

4. There are dangers of contamination of air and water, and spread of infection through flies.

5. It is difficult to manage in towns having a large population.

6. Even if suitable soil is available and the trenching ground is properly managed, the place still breeds flies and becomes a menace to the public health.

7. The transfer of night-soil from pails to buckets, and from buckets to carts creates a great nuisance.

Disposal of Slop Water

The conservancy system does not provide for the removal of domestic or other waste water, and to carry this out efficiently in towns and villages is a very difficult problem,

for these are no less impure than the ordinary sewage of water-closet towns. A system of drains, therefore, for the removal of such water is necessary. The slop water from isolated village houses is usually conveyed by pervious (*kutcha*) drains, which are merely shallow open trenches or elongated cesspools, to the nearest tank, ditch, garden, or open land. These drains are very inefficient and their general plan and construction are faulty in the extreme. Their sides have no proper slope to prevent the falling in of loose earth, their bed no sufficient inclination to permit the water to pass with a velocity sufficient to carry off solid filth and prevent their deposition. The consequences that may follow such a practice are obvious. They form a suitable breeding place for mosquitoes, flies, etc., pollute the neighbouring water-supply after saturating the soil by soakage, and during the rains form dirty, fermenting and offensive puddles. Another common defect of drains in Indian towns or villages is the want of any suitable outfall. In most cases they terminate in tanks and *dobas*, or lead into the open land, *e.g.*, the rice fields and marshy places, which remain sloppy during the rainy season and for some time after. During all this time the village drains remain full of water and thus keep up that saturation and humidity of the sub-soil and foundations so detrimental to the health of the people.

Weeds and other small plants growing in these drains materially impede the free flow of their contents. Arrangements should, therefore, be made to remove this vegetation periodically and to maintain the level of these drains. But by far the best method is to have drains either made *pucca*, or constructed with some non-absorbent material, such as channelled Ranigunge or half-round patent-stone pipes, to prevent soakage. Wherever possible all drains should be V-shaped on section so that a small amount of water will suffice to flush them, and very little water will accumulate in the narrow bottom of the drains. Large drains should also be similar in section, but the bottoms may be rounded.

Sewage can be best disposed of by irrigation over agricultural lands or open fields, while the slop water of individual houses may be collected in suitable vessels or pits and then removed to some cultivated land for final disposal.

WATER-CARRIAGE SYSTEM

Waste water consisting of liquid and solid human excreta, together with liquid refuse from cowsheds, stables, houses, factories, etc., is known by the term **sewage**. Waste-water from houses, etc., unmixed with solid excreta is usually known as **sullage**.

In this system the waste water and excretory products are carried away through a system of sewers from the

immediate neighbourhood of habitations by a flush of water. Owing to the initial expense incurred in its outlay and also for the abundance of water-supply that it demands, the water-carriage system cannot be introduced everywhere. It also necessitates the installation of certain sanitary fittings in every house. It appears to be cheaper in the long run, and is the cleanest, quickest, and most sanitary method of removing night-soil. For these considerations the water-carriage system is indispensable in big towns. But for successful operation the following conditions are essential, *viz.*, (1) an abundant supply of water, (2) good drains and sewers with proper ventilation, (3) sufficient fall to give the required velocity to the sewage, and (4) proper means for utilising the sewage.

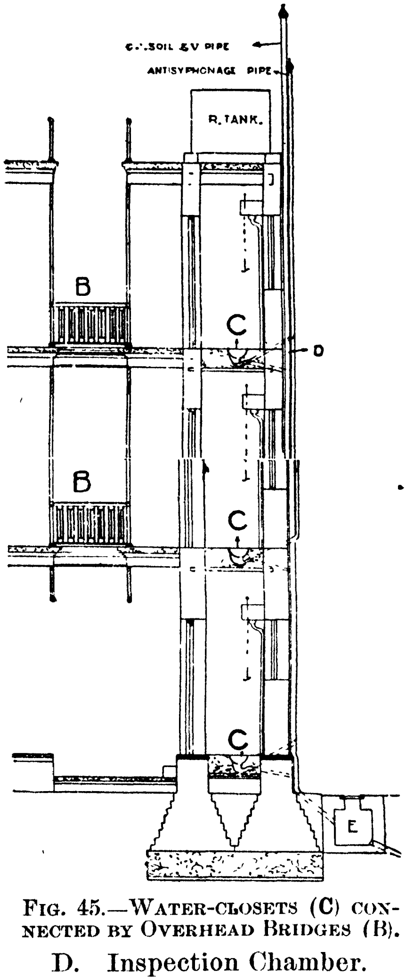

FIG. 45.—WATER-CLOSETS (C) CONNECTED BY OVERHEAD BRIDGES (B).

HOUSE DRAINAGE

A complete system of house drainage consists of

A. Water-closet and Connecting Pipe.
B. Soil Pipe.
C. House Drain.
D. Inspection Chamber.
E. Traps.

A. Water-closet.—A Water-closet is a sanitary installation for the reception of human excrement, and having connection with a sewer by a pipe, removes it through the agency of water. A good water-closet should be simple in construction and not liable to get out of order, it should be inodorous, the basin should be of some non-absorbent and indestructible material, the excrement shall fall without any external agency into the proper portion of the closet, and the flushing should be of sufficient force to wash the

basin clean and remove all traces of excreta with a minimum quantity of water.

It should be in a detached portion of the house, or built against the outside wall. At least two of its sides should be open to the outer air. The closet apartment is too often a crammed, dark, ill-ventilated room. In fact no apartment of a house demands more free ventilation than this, yet perhaps there is none which receives less. There should be provision for cross ventilation. When a closet is required for each storey the apartments should form a separate tower connected to the main building by over-head bridges. (*See* figure 45).

A water-closet consists of the following parts :—

1. The closet proper, consisting of the basin, and a trap ; and 2. The flushing apparatus.

1. **Closet Proper.**—The following varieties of water-closets are commonly used :—

(*a*) Valve Closet. (*b*) Siphonic Closet.
(*c*) Wash-down Closet. (*d*) Wash-out Closet.
(*e*) Trough Closet.

(*a*) *The Valve Closet.*—It consists of a stoneware basin with an opening below having a diameter of about 3 in., closed by a water-tight and movable valve fixed by a hinge. The valve opens out on raising the handle and the excreta are received into a metal box, the lower part of which is connected with a siphon trap leading to the soil-pipe. The closet should be flushed immediately after each visit with plenty of water (2 to 3 gallons) from a cistern, and arrangements made for an after-flush, *i.e.*, for a supply of water into the basin after the handle is released. In case of excessive after-flush the basin may overflow. To prevent this an overflow pipe is attached almost at the top of the basin and is carried down into the valve-box with a siphon bent, which by holding water prevents the escape of foul gas.

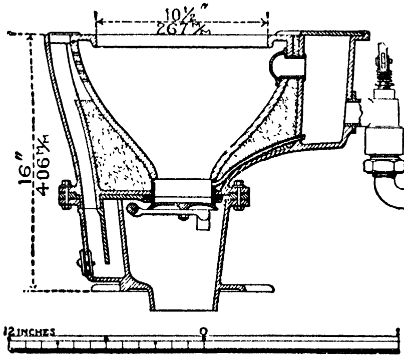

FIG. 46.—VALVE CLOSET.

The advantage of this variety of water-closet is that it is noiseless, and has a large exposed surface of water which prevents the fæces from falling upon or adhering to the basin. Its principal disavantage is that the valve is liable to be dislocated by any substance which gets fixed therein, thus allowing the water in the basin to escape and foul air to enter into closet apartment.

(*b*) *The Siphonic Closet*, also called *Jenning's Century Closet*, has within recent years come into prominence, and though a more expensive appliance it is cleanly and has many points in its favour. It resembles the wash-down closet with this difference that the ascending arm of the siphon trap is continued upwards, so that the water in the basin stands at a higher level and a larger area is exposed and a deeper seal is formed. The descending arm terminates in a second siphon before it joins the soil-pipe. When the closet is used, siphon action is started by the inflow of water both through the siphon pipe and the main pipe, the former discharging water into the descending arm of the siphon the latter into the flushing rim to the basin. The contents of the pan are, therefore, subjected to a *vis a tergo* by the flush and a *vis a fronte* by the temporarily induced siphonage in the trap.

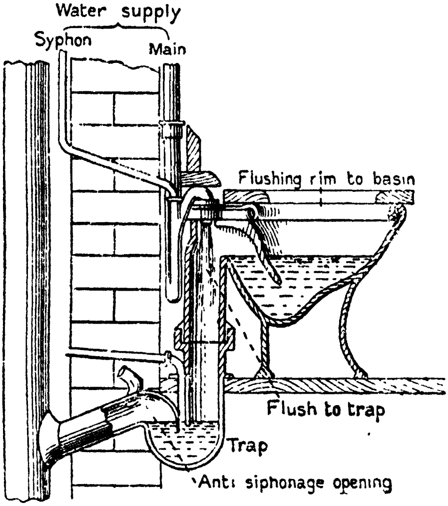

FIG. 47.—THE SIPHONIC CLOSET

(*c*) *The Wash-down or Short Hopper Closet.*—This type of

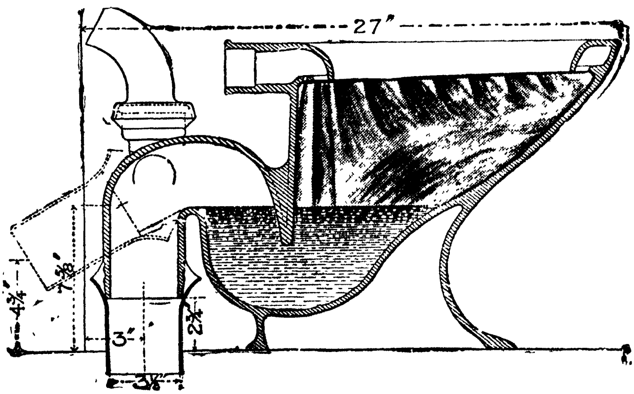

FIG. 48.—WASH-DOWN CLOSET WITH RIM FLUSH SHOWING P AND S TRAPS.

closet is extensively used. It consists of a short inverted cone, the back of which is almost vertical, so that the

excreta may fall directly on the water in the trap without fouling the sides. With a rim flush it can be easily kept clean.

(*d*) *The Wash-out Closet.*—In this a certain amount of water is retained in the pan by a ridge. The excreta will have to be flushed out over this ridge, and, therefore, a powerful flush is required for this purpose. This closet is not without defects, for foul matters are often left behind and the water flowing into the pan is not always enough to cover them.

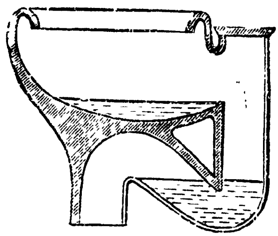

Fig. 49.
Wash-out Closet.

The *Pan Closet* and the *Long Hopper Closet* are not used now-a-days. They are unhygienic and cannot be kept clean.

In selecting a closet preference should always be given to a washdown or short hopper with a vertical back and a rim flush. The valve closet and the siphonic closet are expensive, but can be used for high class work. Whatever type of closet is used none can remain clean without periodical scrubbing.

(*e*) *Trough Closets.*—These closets are suited for places like jails, hospitals, schools, etc. They consist of a long metal,

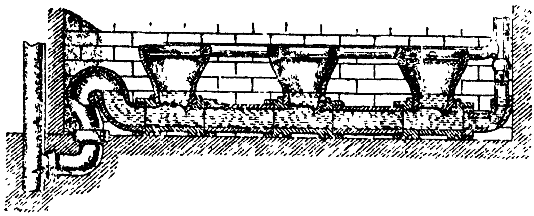

Fig. 50. Trough Water-closet.

masonry, or earthenware trough placed on an inclined plane under the seats of the closets placed side by side, for the reception of the excreta. The trough retains a certain amount of water by means of a weir at its lower end and the excreta are expelled by a volume of water discharged either by an automatic flush, or by an attendant, and carried through a trap placed at the end of the trough. An improvement in the trough closet is made by separate partitions and separate pans attached to one common discharge pipe. The advantages of this type of closet are : (1) One apparatus serves for the use of several persons at one and the same time ; (2) it is cheaper and hardly ever gets out of order. But even with the most careful management it is almost impossible to maintain such a standard of cleanliness as can be secured where separate basins are used.

In India people use the closet in a squatting posture and therefore the seat arrangement is modified by having two foot

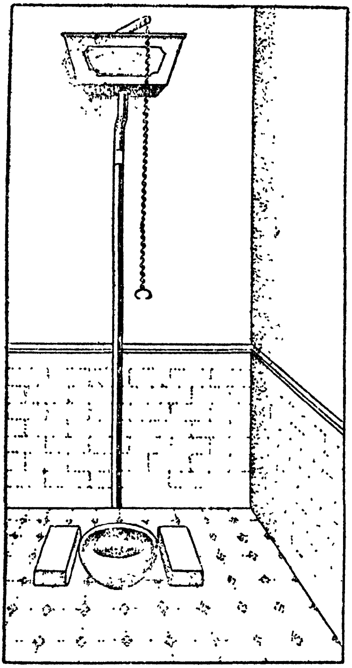

FIG. 51.—WATER-CLOSET (Eastern type)

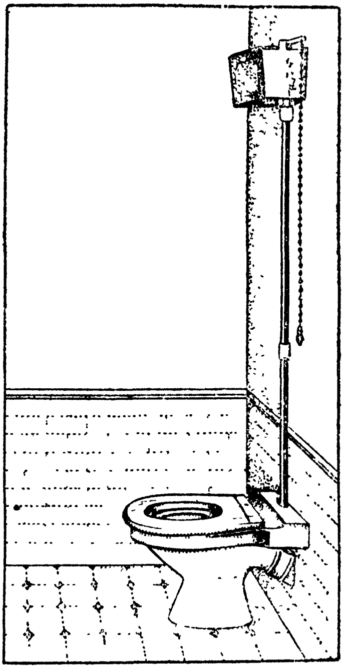

FIG. 52.—WATER-CLOSET (Western type)

rests on either side of the pan proper, (*see Fig.* 51), the pan with the trap being placed on a level with the floor of the closet apartment. The floor and the foot rests may be made

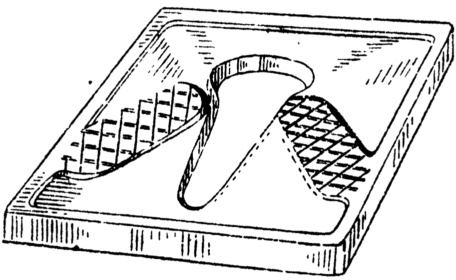

FIG. 53.—SQUATTING PLATE FOR WATER-CLOSETS (Eastern type)

with pătent stone or cement. Separate squatting plates made with marble or enamelled vulcan ware with foot pads

are now available, and may be used for better class work. (Fig. 53). These are impermeable to water.

2. **The Flushing Apparatus.**—The water-closet should be flushed immediately after use; and provision should, therefore, be made for the storage and discharge of water. Water is stored in tanks or cisterns, which should be separate for each closet, connected with a main tank placed on the top of

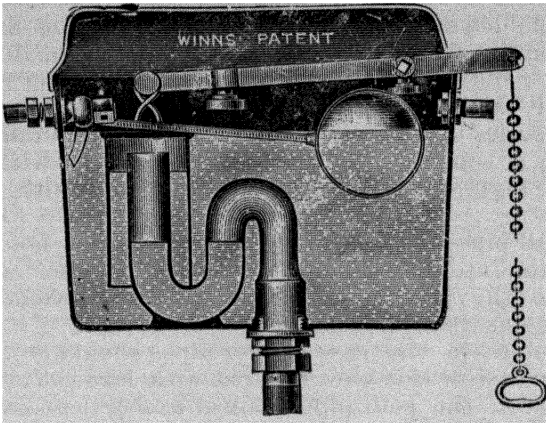

FIG. 54.—SIPHON FLUSHING CISTERN.

the house. The cisterns are usually made of galvanized iron, and should be placed about 4 ft. or 5 ft. above the basin, and the water delivered by pipes of $1\frac{1}{4}$ in. to $1\frac{1}{2}$ in. diameter. The pipes should have as few bends and angles as possible. The water is discharged either automatically, or by pedal action, or by a pull of the chain which puts the siphon of the cistern in action. The best type of flushing apparatus should supply three gallons of water each time; and should fill itself rapidly after being emptied. It should project the water suddenly and forcibly and should supply the same quantity of water every time it is used.

B. Soil Pipes.—These are circular pipes which conduct the excreta from the water-closets to the house drain. They should be either of cast iron, or drawn or milled lead, and laid as straight as possible. Lead pipes are more expeditiously erected and easier of manipulation. They should be exposed right through for ready inspection, and connected with the closet immediately beyond the siphon bend or trap, and carried directly outside the house-wall, to which they should be fixed by tacks. They should have an internal diameter of 4 inches, and be carried clear of windows, 6 to 8 feet above the roof, for the escape of foul gas. The end may either be left open or covered with a wire-gauze dome. (*See* Fig. 63). Whenever possible these pipes should either be fixed on the shady side of the house, or protected by

wooden casing, to prevent the joints being damaged by the tropical sun. To prevent oxidation and rusting, iron soil pipes are coated either with magnetic oxide of iron (Barff's process), or they may be dipped in Angus Smith varnish. (*See* page 26).

When several closets on different floors discharge into a common soil pipe, the transmission of the contents of the upper closets down the soil pipe may cause unsealing of the traps of the lower closets by siphon action. The antisiphonic action is ensured by means of a pipe 2 in. to 2½ in. in diameter fixed on the crown of the trap (on the soil pipe side) and carried through the walls into the outside air. Where a series of such pipes exist, they are generally united either to a separate ventilating pipe or are carried up to above the highest closet and then connected with the soil pipe.

The soil pipe should open directly into the house drain without any intervention of a trap, as it imposes a useless barrier to the passage of the sewage and prevents the soil pipe acting as a drain ventilator.

The joints in the case of lead pipes should be "wiped," and in the case of iron ones caulked with lead. The connection between the soil pipe, be it of iron or lead, with the closet pan, *i.e.*, between an earthenware and a metal, should be absolutely water-tight and is best secured by "Doulton's ceramic joint," while that of the soil pipe with the drain by means of a "ferrule" or a brass or copper tube about a foot long soldered to the lower end of the soil pipe, while the rim of the ferrule rests in the socket of the drain pipe, and the intervening space is filled with cement.

C. **House Drain.**—A house drain is an underground pipe for carrying away discharges from water-closets (received directly through soil pipes) and waste water from house or compound to the sewer. It is usually constructed of some impermeable material such as iron pipes, or circular glazed stoneware socketed pipes, in lengths of 3 feet. It should be laid without any angles or bends, with the socket end of the pipe looking towards the house, on a smooth inclined plane to facilitate easy transit of its contents, and jointed with cement in such a way that there is no projection inwards at site of the joint. If a bend is necessary, it should be by special curved pipes. A branch drain should join the main drain at an acute angle to lessen obstruction to the flow. It is not always possible in a large building to lay down drains in a uniformly straight line, and in such a case it is desirable to have *chambers* for inspection at every change of direction and to continue the drain through the floor of the chamber by means of half channelled pipes. The joints should be made both air and water-tight. The size of the drain varies according to the amount of sewage to be carried. For ordinary

houses it should be about 4 inches in diameter with a fall of 1 in 40, but in larger buildings, such as hospitals, hotels, etc., it should be from 6 in. to 9 in. with a fall of about 1 in 50 and a flow of $2\frac{1}{2}$ feet per second. For all practical purposes the fall should be ten times the diameter of the pipe.

The smaller the drain the better is the flushing and removal of deposit, but in every case it must be large enough to prevent blocking. The drain should be laid on a smooth bed of concrete 6 inches deep. When carried under the basement of the house there should be 6 inches of cement concrete all round, and where the collar of the pipe rests, the concrete should be hollowed out and the joints made both air and water-tight.

Requirements of a good house drain :—

1. A fall that will give good velocity to the current, and pipes with smooth internal surface.

2. Well fitting joints to prevent any escape of sewage or gas.

3. Proper flushing arrangement.

4. All branches from the main drain should have **Y**-joints, *i.e.*, to form an acute angle and not a right angle.

5. A good bed of concrete to secure solidity and prevent disjointing of pipes from uneven settling of house foundation.

6. Good ventilation effected by placing a trap outside the house.

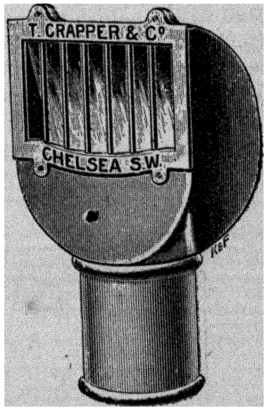

FIG. 55. MICA VALVE BOX OF FRESH AIR INLET.

Ventilation of House Drain.—The house drain should be properly ventilated. Therefore arrangements for the inlet and outlet must be made to ensure a free circulation of fresh air from one end to the other. The inlet opening is situated as near as possible to the trap intercepting the house drain and the sewer. Owing to the situation and construction, the soil pipe is made to act as an outlet, the end of which is carried above the roof and is protected by a wire-gauze dome. The inlet for ventilation is provided by a 6-in. pipe one end of which opens into the inspection chamber opposite the entrance of the drain (*see* Fig. 56) while the other end is carried a few feet above the ground and opens into the outside air. To prevent this from acting as an outlet the top of the pipe is fitted with a sort of a box containing a mica flap (*see* Fig. 55), which admits fresh air from without but closes when there is a reflux of foul gas from the drain.

D. Inspection Chamber.—This is a square masonry

underground chamber, the floor of which is formed by the level of the drain and rendered perfectly water-tight by lining it with cement. It is provided with an air-tight iron cover, while the ventilation is carried on by a 6-in. pipe.

The sewage is conveyed through the chamber by a glazed half-channelled pipe which discharges itself into a trap.

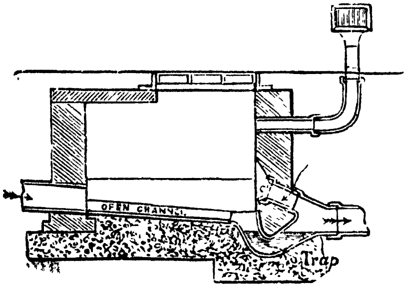

FIG. 56.—INSPECTION CHAMBER.

The floor should form an angle of 30° on either side of the channel. The branch drains which are also made of glazed channelled pipes curved to the proper degree, empty themselves into the main channel. Whenever possible all inspection chambers should be situated in open spaces or yards and not actually within the building.

Although it is generally held that sewer air is not more harmful than drain air, yet a disconnection of the drain of the building from the public sewer is necessary. This is generally done by having a trap interposed between the house drain and the sewer, and is known as the *intercepting trap*. (*See* Figs. 57 and 63). Such a trap, besides having the inlet and outlet ends has two other openings—one near the entrance for acting as an inlet for ventilation and other protected by a lid, just beyond the siphon bend of the trap, for acting as the clearing eye. The following points, re-

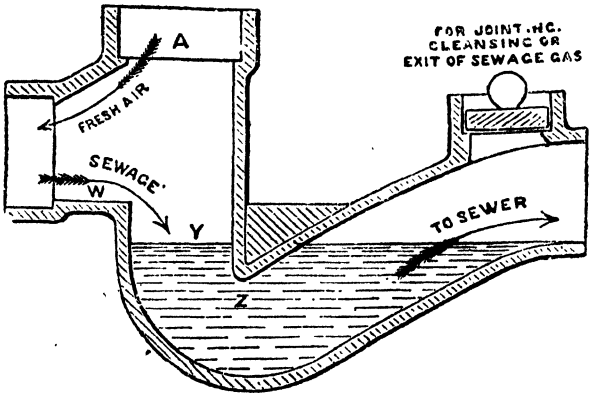

FIG. 57.—INTERCEPTING TRAP.

commended by Parkes and Kenwood, should be observed in selecting such a trap: (1) Where the drain is a 6-in. or a 9-in. pipe, the siphon should be a size smaller than the drain;

(2) there should be a fall of 2 inches or more from the level of the discharging end of the house drain to the surface of the trapping water ; (3) the siphon should provide an adequate seal of 2 or 3 inches of water ; (4) the inlet to the siphon should be nearly vertical whilst the outlet rises at an angle of not more than 45°.

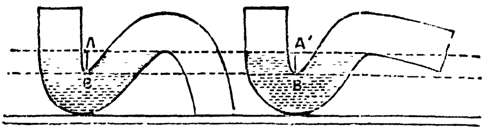

FIG. 58.—S-TRAP AND P-TRAP WITH WATER-SEAL.

E. Traps.—A trap is an arrangement in the drain or waste pipe which acts as a barrier to the entrance of sewer air into a house effected by what is called a *water-seal.* A good trap will completely disconnect the air of one pipe from that of another. A trap in its simplest form is a bent pipe which holds up water and prevents air or gas from passing through.

The *water-seal* of a trap is the distance between the level of the water in the trap and the lowest point of its concave upper surface when the trap is in proper position (A B and A′ B′ ; Fig. 58). It should be ventilated so that it may not be easily unlocked and should possess a water-seal of not less than $2\frac{1}{2}$ inches.

A trap should be self-cleaning with every flush of water ; and have no angles, corners, cracks or projections inside, which might impede the onward flow of any solid matter. It should not be liable to "silt" ; and it should have an opening for cleansing purposes. A minimum-size trap consistent with circumstances should always be selected ; or it may become a little cesspool if the size is greater than can be cleaned by an ordinary flush of water. The following are the usual positions :—

1. Under each water-closet, bath, urinal, sink, etc.
2. Near the junction of the house drain with the sewer.
3. In the open air at the level of the ground to receive slop water from baths, lavatories, etc.

Varieties of Traps.—There are many varieties of traps but the following are generally used :—

The *mid-feather trap*, the "*Bell*" *trap* and the *flap trap* are examples of *bad forms of traps* and are not used now.

1. *Siphon Trap.*—It is simply a bent tube, the bend resembling the letter **S** placed sideways. The water collects at the lower end of **S** and should stand at least $\frac{1}{4}$-in. above the top of the curve. It is the best form of trap and maintains a siphonic action as it always keeps a constant level

water. It is usually provided with an opening placed beyond the water-seal intended for an anti-siphonage pipe. Siphon traps are also named **P**-trap and **S**-trap, according as the direction of the outlet is outwards or downwards. (*See* Fig. 58).

2. *Gully Trap.*—This is placed in courtyards, especially where rain water and waste water pipes open. It should be placed at a distance of about a foot and a half from any wall, and the surface opening should be as small as possible and protected by a grating to prevent evaporation. As it is possible that mud, other debris and solid particles may be swept into the gully with the inflowing surface water, this trap is so made that these settle at the bottom, which may be removed periodically.

Under certain cicumstances a trap may fail to perform its functions, *viz.*—(1) Evaporation of the water-seal; (2) from deposit of solids or silt; and (3) siphon action.

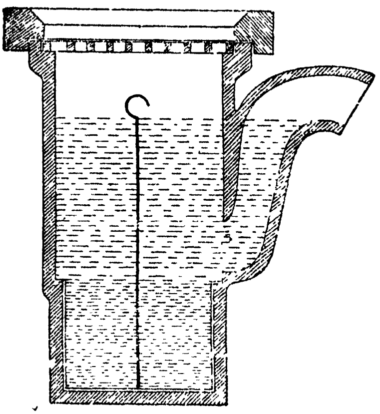

FIG. 59.—GULLY TRAP.

1. *Evaporation of the water-seal* is due to disuse of the trap, thus giving time for evaporation of the water. This generally happens when the house is left unoccupied for sometime.

2. Traps also become useless from being blocked with deposit of solid matter due to imperfect setting, or inefficient flushing, or to insufficient fall in the house drain.

3. *Siphon action.*—This generally happens when the traps of the soil-pipe and closets are unventilated. To understand this examine figure 60 which represents three closets at different levels and where the traps are not ventilated. Imagine that each trap of each closet is full of water and the soil pipe and the branch pipes are empty. The effect that follows the use of the upper closet after flushing is shown in the figure. The descending column of water rushes into the pipe and leaves behind it a partial vacuum. The outer air, therefore, reaches the soil pipe through the way of least resistance, generally through the closets below (2 and 3). The traps of the lower closets are thus siphoned and left empty. If the trap be pierced at the top the air presure will be established at both ends of the leg. It is thus that a ventilating opening to closet trap breaks the flow and throws enough water back into the body of the trap to preserve the waterseal.

THE TESTING OF DRAINS, SOIL PIPES, ETC.

Testing of drains and their branches is always necessary, and is employed not only for new sanitary installations and during the progress of the work to find out if they have been properly constructed, but also in cases of old drains to ascertain whether they are still in good order. The following tests are commonly used :—

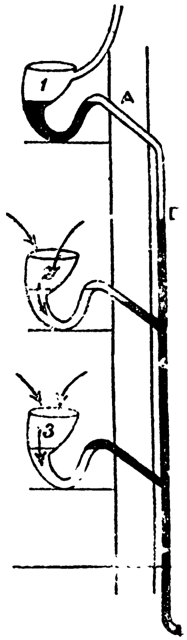

FIG. 60.—Three closets at different levels explaining siphoning of traps

1. *Hydrostatic or Water Test.*—This is especially used in new drainage work. To carry it out plug the lower end of the waste and soil pipe and each branch fitting with suitable water-tight covers and fill the newer system with water. If the level of the water falls or if the drains do not fill at all, it indicates a defect at some point and the joints should be carefully examined. It is, however, a very severe and unequal test when applied to a long length of perpendicular pipes. For instance when the soil pipe is filled with water the pressure is greatest at the lowest point of the pipe which may in consequence burst. But this test can be used for testing drains, and when used for large installations it should be taken up in sections.

2. *The Smoke Test.*—It is a handy and fairly reliable test and consists in filling the whole sanitary system with smoke so that it may find its way through any leaky joint or defective trap, and thus demonstrate the exact position of the faults. In applying this test the tops of the waste pipe and soil pipe must be properly closed and the smoke applied through the air inlet of the intercepting trap at the junction of the house drain and the

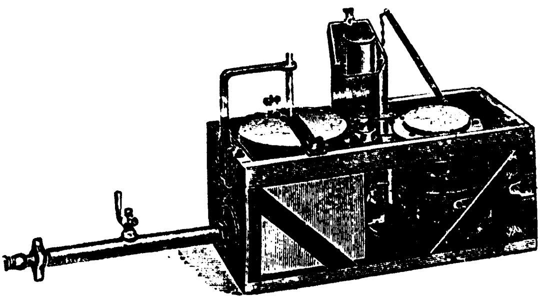

FIG. 61.—SMOKE TESTING MACHINE.

sewer. For this purpose special smoke testing machines

are available. They consist of a double-action bellows or motor by which the smoke is forced, a cylinder or receptacle in which smoke is generated by burning oily cotton waste, and a pipe connecting these and carried into the drain. Smoke rockets are sometimes used for the same purpose but the results are not so good as when introduced by the special machine. This test is quite practical and useful and may be applied either in vertical soil pipes, drain ventilating pipes, or inspection chambers.

3. *Chemical Test.*—This test is applied by pouring two or three buckets of hot water with a fluid drachm of some volatile oil down the highest water-closet, or down the pipe from the highest available point. If on examination a peculiar smell is perceived the leakage will be discovered. This test is useless.

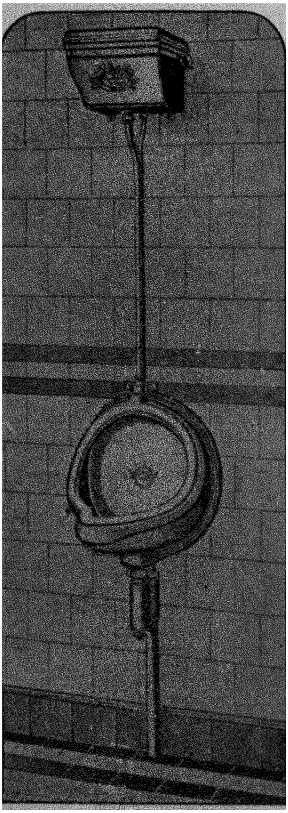

Fig. 62.—Urinal with Flush.

4. *Pneumatic Test.*—It consists in driving air under pressure into the drain and soil pipe by a pump, to which is attached a pressure-gauge, after all the openings have been securely plugged. The presence of any leakage is evidenced by lowering of the pressure in the gauge, and the point of leakage by a hissing sound.

Baths, Sinks and Urinals

Sanitary baths and sinks are now fitted in all modern houses. These should be located in properly ventilated and well lighted rooms. The waste water should be carried through lead pipes, which are easily bent and non-corrosive, and jointed to the outlet of the sink or bath. Both these discharge waste water, and the pipes carrying the water in time becomes foul with grease and organic matter giving off an offensive smell when decomposed. It is therefore necessary that the outlet pipes should be properly trapped and carried direct into a gully trap or connected with the soil pipe. To prevent siphonage of the water from the traps arrangements should be made for ventilation and anti-siphonage.

Urinals for private houses should be located in the bath rooms, but it is always desirable to avoid fixing urinals

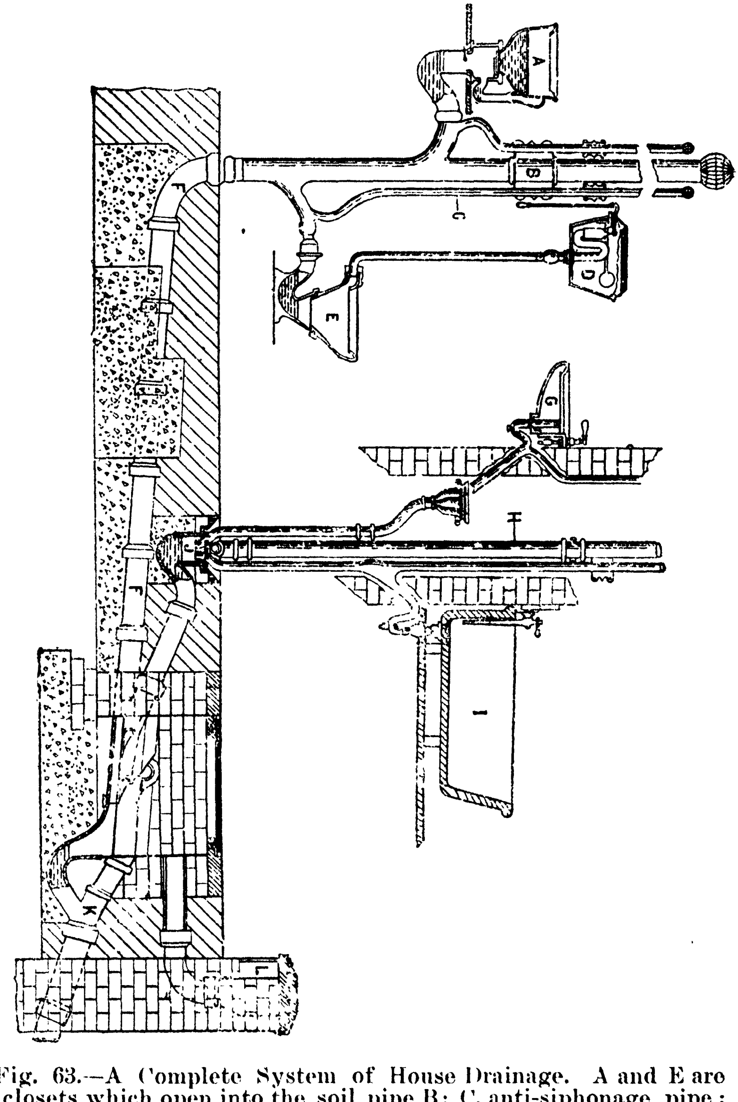

FIG. 63.—COMPLETE SYSTEM OF HOUSE DRAINAGE.

Fig. 63.—A Complete System of House Drainage. A and E are two closets which open into the soil pipe B; C, anti-siphonage pipe; D, flushing cistern opening into the closet E; F, house drain laid on a bed of concrete; H, rain water pipe; G, wash basin; I, bath tub. These empty into the gully trap J. K, intercepting trap placed in the manhole chamber intercepting the house drain from the sewer. L, inlet opening for ventilation. The soil pipe and the ventilating pipes are carried above the roof and are protected by wire gauze, they act as outlets

within the house as they create considerable nuisance unless properly flushed with plenty of water. They should be simple in construction and provided with an automatic flushing arrangement. All parts of the appliance with which urine comes in contact should be exposed to the flush to avoid fungus growth. Urinals for public use should always be provided. They are of great use in schools, clubs, factories, etc. They should be made with some non-corrosive material, and no metal apparatus should be used as they are liable to corrosion. Various firms have designed many excellent contrivances for minimising the nuisance. The Urinal Range (*see* Fig. 42) is designed by Messrs. Doulton & Co. A good type urinal should have a trap just below the pan (*see* Fig. 62) and the pipe should be carried outside into the open air and should open either into the soil pipe or taken separately into the drain. On no account should it open over a gully inside the room.

SEWERS

A sewer is an underground structure in the form of a pipe or brick channel for the removal of waste water, rain-

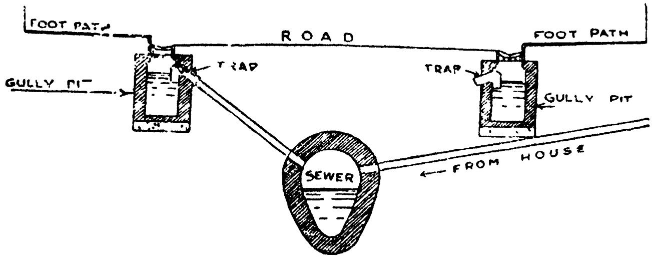

FIG. 64.—POSITION OF SEWER.

water and sewage by gravitation. This system of sewage removal is known as the "combined system." Two sets of channels are sometimes provided—one for carrying the rain and waste water, and the other—smaller one—for sewage alone. This method is called the "separate" system. Those carrying the waste water take the shortest route to the nearest water course or river, where they empty themselves, the other set conveys the sewage for final disposal by one of the methods to be presently described.

The *advantages* claimed for the separate system are :—

1. The sewers required are of smaller dimensions and so easily flushed, consequently there is less deposit.

2. The sewage is uniform in quality and smaller in quantity.

3. Purification and utilization are effected with less difficulty.

4. In a known population estimation of the total bulk of sewage can be done from the allotment of water per head.

5. Cheaper than the combined system.

The *disadvantages* are :—

1. Two sets of pipes are required for every house and so a wrong connection may be established by mistake.

2. The rain and storm water may wash away much that would contaminate a stream.

3. The flushing effect of storm water on the sewage is lost.

These objections are, however, not of much consequence, and the adoption of either plan depends upon the local circumstances.

Sewers up to 18 inches in diameter are circular, and made of either reinforced concrete or glazed stoneware pipes joined together with cement When of larger dimensions they should be of brickwork and cement. Iron pipes should be coated with Angus Smith solution to prevent corrosion. The best sewer in case where the volume of sewage undergoes great fluctuation is ovoid or egg-shaped with the smaller end downwards. This gives a greater depth of sewage and less contact with the inside walls ; consequently there is less friction. Besides, it is much stronger and offers greater resistance to outside pressure.

Earthenware pipes must be laid on a bed of concrete and the joints should be thoroughly cemented, and the inside made absolutely smooth. No public sewer should have a diameter of less than 9 inches as then it will carry any article which can come lengthwise around the traps and bends in 4 inches soil pipes and house connection.

Sewers should be self-cleansing, and constructed with a sufficient gradient. The size should be proportionate to the volume of sewage they have to convey. To prevent deposition in pipes of 12 to 25 inches in diameter the velocity should be $2\frac{1}{2}$ feet per second, and in sewers of larger dimensions 2 feet per second. A less gradient is necessary for larger sewers to produce the same velocity as in smaller ones. The fall should be equable, and all sudden changes in the level should be avoided ; a sewer of 10 feet in diameter should have a fall of 2 feet per mile. To calculate the velocity of the flow through sewers the following formula is used :

$$V=55\sqrt{D\times 2F}$$

V=velocity of flow in feet per minute ;
D=hydraulic mean depth ;
F=fall in feet per mile.

If A=the sectional area of current of fluid, V×A= discharge in cubic feet per minute. The *hydraulic mean depth* is the sectional area of the current of fluid divided by the wetted perimeter, *i.e.*, the portion of the circumference of

the sewer in contact with the flowing fluid; in circular sewers running full or half full, it is one-fourth the diameter.

All sewers must be laid with as few bends as possible and the junctions made at acute angles to allow the sewage to enter the direction of the flow. The junctions from house drains should be so made as to allow the discharge from the house drains to be in the direction of the main current. Curves, if there be any, should be gradual, the radius of the curve being not less than ten times the cross-sectional diameter of the sewer; thus if a sewer be 5 feet in diameter the curve should never be less than 50 feet.

Inspection, Cleansing and Ventilation of Sewers

In the sewerage system it is necessary to provide adequate means for periodical examination, cleansing and removal of deposit. To meet these ends manholes should be provided for. These are shafts sunk from the surface of the ground through which a man can descend into the sewer. Branch sewers are made to join the main sewer in these manhole chambers.

Near the upper ends of sewers the flow of sewage is very small, liable not to be able to carry solid filth, thus forming deposits. Similarly in low lying level districts on account of the lack of falls it may be necessary to lay the sewers with very small gradient, and the velocity, therefore, is insufficient to prevent deposits. Hence it is desirable to make special provisions for regular flushing to make them self-cleansing by the use of automatic "Flush Tanks." A flush tank is a masonry cistern built in the street above the grade of the sewer, filled by a constantly running stream of water, and emptied by automatic devices into the sewer. They have a capacity of 150 to 500 gallons, but more the water used the better is the flush.

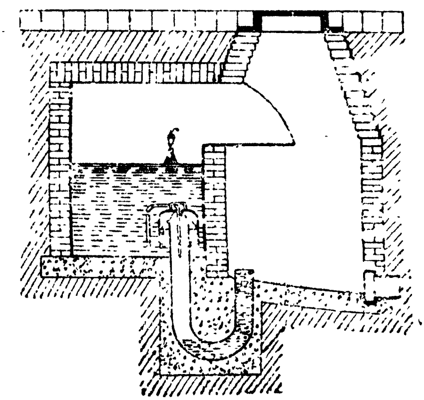

Fig. 65.—Flush Tank and Manhole.

Flush tanks may be combined with a manhole. (*See* Fig. 65). This has the advantage of allowing inspection both of the sewer and of the tank, and is cheaper.

Sometimes flushing is done by temporarily damming the sewage and then suddenly releasing it when a sufficient head

is formed. This is done by flushing gates. A hose pipe run into a manhole from a hydrant may often be used with advantage.

The methods most commonly employed during dry weather are either a sudden discharge of a large volume of water through the manholes, or discharging water from large automatic flushing cisterns placed near the head of the sewers. The method employed in Calcutta is to allow the tidal water of the river Hughly to flow into the sewers through flushing gates which are opened when the water rises to a certain height. The value of rain water in flushing the sewers should be kept in mind.

Ventilation of Sewers.—In every sewer where the sewage is well diluted, the flow rapid and the flushing efficient, deposition of sediment does not occur, and the air does not become very foul. But owing to the constant variations of the flow of sewage some deposit forms on the sides, which not only undergoes putrefaction but gives off putrefactive ferments to the sewage flowing by. The tendency to such deposits is less in pipe sewers than in brick ones. The gases evolved by decomposing sewage are combustible, and one should, therefore, be careful in carrying an unprotected light into a newly opened manhole, old drain or cesspool. Ventilation of sewers is therefore necessary to dilute such gases.

The simplest way of ventilating sewers is by perforated manhole covers having a tray or dirt-box below to catch dirt. stones, etc. These should be at a distance of about 100 yards from each other. Some of them act as inlets while others as outlets. The air which escapes through these ventilators is rapidly diluted by fresh air and so rendered inoffensive.

Another method is to fix long iron shafts at suitable distances along the length of the sewers. These are carried sufficiently high into the air well above the top of the neighbouring house for the exit of sewage air or gas into the atmosphere. Street gullies must be efficiently trapped to prevent mud and sand from entering the sewer and the sewer air from escaping out of it.

Disadvantages of Sewers.—1. Sewers being closed conduits may cause effluvia to enter into houses; but if they are properly constructed, flushed, trapped and ventilated this may be prevented.

2. Any leakage, etc., may contaminate the nearest water-supply. A sewer may leak for various reasons: from cracked joints of pipes, sinking of foundations, imperfect joining or lying, and by the penetration of roots through faulty joints and cracks.

Outfall Sewers.—In every case an outfall sewer must be large and free so that no obstruction to the discharge of sewage may occur. The outfall must be below the level of

the water, independent of the tides, and the opening guarded by a valve to prevent the entrance of water. Where sewage is tide-locked for several hours it should be conducted into especially constructed tanks or reservoirs and then discharged into the river or sea at suitable states of the tide. Sometimes sewage may have to be carried across a river or a valley by bridging, but this is not always practicable when the outfall sewer lies on a lower level. Under such circumstances it should be carried across by the help of an inverted siphon laid in the valley or in the bed of the river. Should the velocity of the current be not sufficient, accumulation and consequent blocking of the siphon with solid matter might take place; therefore steps must be taken for straining the sewage and occasionally flushing the siphon.

Pneumatic System of Sewage Removal.—In the case of low-lying areas, where removal of the sewage by a gravitation scheme cannot be efficiently carried out for want of a proper gradient, or where tank sewers are productive of nuisance, recourse has to be had either to some system of periodical pumping to raise the sewage to a higher level or to one of the following systems:—

1. *The Shone System.*—In this system the transmission of the sewage is effected by means of compressed air. This is conveyed from a central station to *ejectors* or cylindrical reservoirs placed for the reception of sewage under the ground at different parts of the town. The ejectors are made of varying sizes, from fifty gallons capacity upwards. When the reservoirs become full a valve opens and admits compressed air by means of a float acting on a counterpoised lever. This propels the sewage forcibly either into a sewer at a higher level or directly into the outfall. The regurgitation of the sewage is prevented by a ball valve in the pipe sewer, and as the ejectors empty themselves the sinking of the float shuts up the valve of the compressed air tube and allows a fresh quantity of air to enter. On a flat surface where a suitable fall cannot be secured this system gives a proper gradient to the sewers and acts admirably.

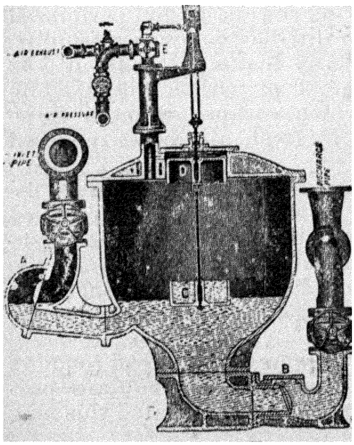

FIG. 66. THE SHONE EJECTOR.

This system has been adopted in Bombay and Karachi. But in India owing to the heavy rainfall considerable

difficulty is experienced in coping with the increased bulk of sewage in the sewers. Under these conditions the ejectors are practically powerless.

2. *Liernur's Pneumatic System.*—In this system there are two sets of pipes; the one smaller in diameter for the removal of waste water; and the other larger (5 in.) in diameter for the removal of sewage proper.

The propulsion of sewage is effected by means of a powerful air pump from a central station, where the sewage is finally sucked into a steam concentrator and then heated to about 100°C. after the ammonia has been fixed by the addition of sulphuric acid. The dried sludge is used as a "poudrette." This system is complicated and causes clogging of the pipes with fæcal matter. But in low lying places, where suitable gradients for sewer are difficult to secure and where the water supply is limited, this system works well.

CHAPTER XIII

DISPOSAL OF SEWAGE

THE primary object in the disposal of sewage consists in changing the different organic matters from the unstable form in which they exist to stable chemical compounds. This result is obtained by the action of micro-organisms. The average sewage consists mainly of water with variable quantity of solids and liquids representing the waste products of the community. The character, however, is very variable depending upon the amount of water consumption, admission of rain water, the character of the effluent from different industries, etc.

The final or ultimate disposal of sewage in either the dry or wet system is a matter of the utmost concern to the sanitarian; for upon the efficiency with which sewage is disposed of depends largely the general health of the people. Possibilities of its acting as a source of danger to the public in Western countries are rather remote, inasmuch as almost every town or village has a separate filtered water-supply. But in India things are different: in villages the water-supply is almost always scanty, and the people generally have recourse to any available source of water, and consequently the pollution of a tank, river, or stream is a matter of great consequence affecting as it does the health of the community.

Composition of Sewage.—Fresh town sewage has the appearance of dirty water with solid lumps floating on it. These lumps rise and fall as the gases of putrefaction are given off. Calcutta sewage contains about 95.6 parts per 100,000 of suspended matter during the months of May and June, and 85.9 parts per 100,000 between August and October. The important constituents of sewage are the organic matters, consisting of proteins and their products of decomposition, carbohydrates, urea, fats and soap. Unless the sewage is very fresh urea is rarely found as such as it is readily converted into ammonium carbonate. Proteins contain carbon, oxygen, hydrogen and nitrogen, and some contain sulphur, phosphorus and iron in addition. Some are soluble in water, while others remain undissolved and in suspension. The carbohydrates include sugar, starch and fibres of wood. Some of the sugar may be converted into alcohol by fermentation. The chief source of chlorine in domestic sewage is urine. Sometimes it is derived from salt present in the water. The sewage of Calcutta at times contains as much as 70 parts per 100,000 of chlorine, of

which 60 parts have been derived from the river Hughli. A certain amount of colloidal matter is also found in sewage. Its presence is of some significance as it precipitates rapidly on the surface of the filtering material and causes clogging. The same action also takes place when sewage is used for irrigation and is the cause of sewage sickness.

Before discussing the different processes employed in the purification of sewage it is necessary to understand the changes that take place before it becomes stable and harmless. Nature, in course of time, will purify any sewage, but the unaided natural process causes nuisance and offence because the putrefactive changes result in escape of offensive gases, and the sewage proteins require oxygen for their metabolism, which, if taken up from water, may destroy fish life. Therefore such measures should be taken which will assist nature in transforming the complex sewage into simple elements and at the same time make it harmless. The natural process of breaking down the various organic matter of sewage takes place at different stages, and is chiefly carried out by the bacteria present in it. Proteins are first broken down into peptones and albumoses, and subsequently into amino-acids, and then into ammonia, phenols, aromatic and fatty acids. All these substances contain nitrogen in the form of NH_2 and require oxygen. Part of the nitrogen remains combined with hydrogen and carbon, part is liberated as nitrogen and the rest is converted into nitrous acid. The final products of decomposition of amino-acids are oxidised forming water, CO_2, nitrites and nitrates. Some sulphuretted hydrogen gas is also formed. The carbohydrates are decomposed into CO_2, hydrogen, butyric and lactic acids, and sometimes alcohol. Fats are broken down more slowly than proteins, since they must first be emulsified before being acted upon by the bacteria. They are eventually hydrolyzed into CO_2, hydrogen, and methane.

The chief methods of disposal of sewage are mainly *(a) Dilution*, and *(b) Purification*.

A. Sewage Disposal by Dilution.—This is the readiest method of sewage disposal, and provided the dilution is sufficient it is the proper method. But there must be a volume of water sufficient to permit of aerobic bacterial action which will effect a complete break-down of the organic matter and at the same time will not destroy fish life, *i.e.*, the oxygen content in the stream should not be materially reduced. The current must be sufficient to prevent silting up of the stream, and there should not be any possibility of depositing floating materials on the shore. This method of disposal has until recently been adopted by almost all seacoast towns and by towns situated on the tidal waters of estuaries. But in recent years pollution of bathing beaches, especially in America, has resulted from adoption of this

method. This evil has been counteracted either by the partial purification of the sewage to the extent of removing solid matter by means of screens or sedimentation tanks, or by chlorination before discharge.

In England the method of discharging sewage into rivers was formerly practised, but the conditions became so bad with the small stream and large tributary population that a law was passed prohibiting the pollution of rivers, and several Commissions were appointed by the Government to study the problem. In fact the Commission declared that the proper method of purification of sewage was by distributing on to land, and distribution of sewage by *broad irrigation*, was carried out extensively in England. Until recently Chicago was able to discharge its sewage into the Illinois River by dilution with water drawn from the Great Lakes, but the growth of the city and restriction placed on the withdrawal of water from the Great Lakes have made it imperative to carry out large purification works for dealing with sewage. The sewage of London and Glasgow is first partly treated by the activated sludge method before discharging into the estuaries of the Thames and the Clyde.

Untreated sewage should not be discharged into any river in India where the dangers are even greater than in any of the Western countries. Under certain conditions the sewage may be discharged without a preliminary purifying treatment into the sea provided it is discharged well below the ebb-tide flow, so that it may at once be carried away from the shore and diluted by a very large volume of water. It should, however, be noted that self purification of polluted water takes place much more rapidly in the tropics than in other Western countries. As regards the bacteriological quality of the effluent required when it is discharged into a river, it is not possible to lay down any standard of any kind. But it is desirable to remove suspended solids by sedimentation or septic tank action. At Dacca (in Bengal) the septic tank effluent is disposed of by irrigation during the dry season, but during the rainy season it is discharged, after a short period of settlement in detritus tanks, into two tanks of 6,000,000 gallons capacity. In the case of a flowing river the dilution required is less than in the case of stagnant water. That a river is capable of disposing of quite a large quantity of sewage is seen in the case of the Bidyadhari river where the Calcutta sewage is discharged in a crude state without creating any nuisance.

B. Sewage Disposal by Purification.—The different methods of sewage purification may be described as follows:—

1.. **Intermittent Downward Filtration.**—By this method sewage is purified by the action of the soil which acts as a mechanical filter, and for this purpose a porous soil should

always be selected. In the words of the Royal Commission on Metropolitan Sewage Discharge, filtration means "the concentration of sewage at short intervals, on an area of especially chosen porous ground, as small as will absorb and cleanse it; not excluding vegetation, but making the produce of secondary importance. The intermittency of application is a *sine qua non* even in suitably constituted soils wherever complete success is aimed at." But for this purpose the same soil should be used on the intermittent principle, *i.e.*, should have alternate work and rest. The purification is chiefly effected by soil bacteria or the nitrifying organisms which exist in large numbers in the superficial layers of all soils, specially in lands rich in organic matter. These organisms require air and oxygen for their development and by feeding on the organic substances of the sewage cause their oxidation. For successful filtration suitable land must be prepared after the fashion of large filter beds, *viz.*—

1. The bottom of the bed should be efficiently drained by means of porous drains laid 6 feet below and 10 feet apart; over this are placed large broken stones or gravel, and on top the natural porous soil.

2. The surface of the land must be properly sloped to allow the sewage to spread over the whole area.

3. The sewage should be distributed by surface channels, and the land divided into blocks, each one being irrigated for six hours and allowed to rest and aerate for eighteen hours. By this means the soil is prevented from becoming clogged and re-aeration is established.

The land may conveniently be laid out in ridges and furrows, and cultivation may be carried on the ridges while sewage is permitted to flow down the furrows. The effluent which comes out of the sub-soil drain is pure, and does not putrefy, and can be discharged into any river or stream. This method is simple and efficient where plenty of suitable soil is available. One acre (about three bighas) of filter bed, if especially prepared, will dispose of the sewage of about 3000 persons.

2. **Broad Irrigation or Sewage Farming.**—This is adopted where suitable land is available in the neighbourhood of a town and is the oldest type of scientific purification of sewage. In the interpretation of the Royal Commission on Metropolitan Sewage Discharge, broad irrigation means "the distribution of sewage over a large surface of ordinary agricultural ground, having in view the maximum growth of vegetation (consistently with due purification) for the amount of sewage supplied." The soil should be reasonably porous, and the land selected should be so situated as will allow the sewage to flow by gravitation. It may, however, be necessary to underdrain the land if the soil be not very porous to carry away the excess of effluent to the nearest

water-course. The sewage must be discharged on to the land in a fresh condition and the coarse portions removed by precipitation or sedimentation. Irrigation of sewage should not be continuous, but must be intermittent, so that aeration of the soil can take place during the period of intermission. The land is laid out on the ridge and furrow system and the sewage flows down the centre of the ridge towards the furrow. Ordinarily one acre of land is required for about 100 persons in temperate climates, but if there be a preliminary precipitation, and particularly in India where evaporation is greater, a smaller area would suffice. It has been observed that during the rains it is rather difficult to take care of the sewage and prevent water-logging.

This method can be profitably carried out in India where land is fairly cheap, and even in the neighbourhood of houses without any danger to health. This method has been extensively adopted for the disposal of sewage in India. Broad irrigation with subsequent farming is practised in many towns in the Punjab and United Provinces with very little preliminary treatment and with some success. But it is desirable to locate the farms at a fair distance from towns or places of human habitation. By this process about 90 p.c. of the total suspended matter and bacteria can be removed from sewage. The effluent, however, is putrescible as there has been no change in the remaining organic matter. Immense crops of coarse grass, sugarcane, plantains, and other vegetables may be cultivated with profit. Badly managed farms, where more sewage is thrown than the land can purify, or where the sewage is discharged without any intermission, may cause the ground to become sodden, and by retarding purification create a nuisance.

3. **Chemical Treatment of Sewage.**—This is effected by the addition of certain chemical agents which act as precipitants and carry down suspended matters with some dissolved organic impurities of the sewage. The clear supernatant fluid called the *effluent* may be further treated or discharged into any water-course or on to any field. The *sludge* or the precipitate is then pressed into cakes and sold as manure. The chemicals commonly used for the purpose are :—

1. *Lime.*—It combines with the carbonic acid of the sewage forming an insoluble carbonate of calcium and also with some of the organic bases of the sewage; the precipitate falls to the bottom forming sludge. But if lime is added in excess, both the sludge and the effluent become alkaline and decompose rapidly. Usually twelve grains of quicklime are required for every gallon of sewage, but the quantity employed varies with the nature of the sewage. This method though simple and cheap is ineffective.

2. *Sulphate of Aluminium.*—This causes a flocculent precipitate which entangles and carries down most of the

suspended organic matters. Lime may also be combined with alum in the proportion of five grains of each to every gallon of sewage.

3. *Sulphate of Iron or "Copperas."*—This when added to alkaline sewage, or to sewage previously treated with lime, forms a copious precipitate of hydrated protoxide of iron which carries down suspended organic matters. Two to five grains of this salt are added to each gallon of sewage.

The disadvantages of the chemical treatment of sewage are numerous, and it has hardly ever been practised in India, and in places where it has been in use it is rapidly being given up. The sludge which falls to the bottom of the settling tank is very bulky, and the difficulties and expenditure attending its safe removal and disposal are great. Moreover, the sludge, containing organic and mineral matters and about 90 per cent. of water, has very little manuring value; and the effluent is not free from pathogenic organisms. In fact the microbes are not removed but the sewage is simply clarified.

4. **Biological Treatment.**—This process, instead of precipitating suspended matters, reduces the complex organic matters present in the excreta into simpler substances by the action of bacteria and other micro-organisms. In fact the disposal of night-soil by trenching, sewage farming, and intermittent downward filtration are really biological methods inasmuch as the ultimate results are obtained through the micro-organisms present in the soil. Within recent years, however, the biological disposal of sewage has been more thoroughly studied with considerable success, and different methods have been introduced for this purpose. Their main action depends upon the two kinds of microbes present in the sewage, *viz. aerobic* and *anaerobic*. The anaerobic organisms are chiefly concerned in reducing the organic subtances of the sewage into simple chemical products, by breaking down, digesting and liquefying them. The albuminoid materials, cellulose and fats are split up into soluble nitrogenous substances, fatty acids, ammonia, gases and derivatives of phenol. This action is encouraged by subjecting the sewage to anaerobic fermentation in the *Septic Tanks*. After the sewage has been thus prepared for the oxidation of the organic matter remaining partly in true suspension, partly in colloidal solution and partly in true solution, it is passed into *percolating filters* or *contact beds* for the aerobic organisms to convert the ammoniacal substances into nitrites and nitrates. The installation of contact beds in which the sewage is held up for a certain period in contact with some solid media coated with bacterial growth has been given up, and the oxidation of the organic matter is now effected either in *percolating filters*, or by means of the *activated sludge method*, where the sewage is purified by oxygen provided by

driving compressed air in tanks in a manner which ensures intimate contact with the crude sewage after fine screening only.

Septic Tanks.—Many varieties of biological installations, such as those of Scott-Moncrieff, Stoddart, Cameron and others, are in existence. This installation was first devised by Cameron of Exeter under the name of the *Septic Tank System*. But the first systematic study of the biological

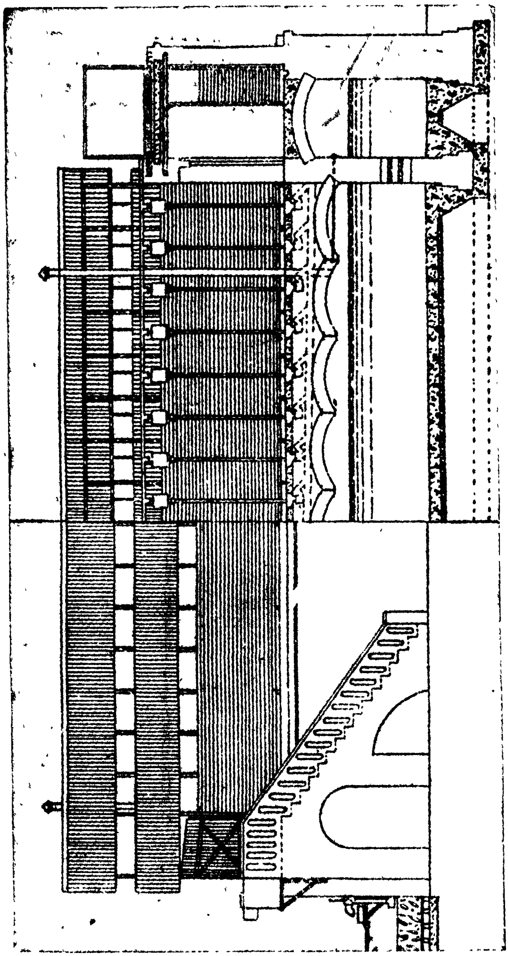

Fig. 67.—Septic Tank Latrine.

process of the treatment of sewage in the tropics was undertaken by Fowler and Clemesha in 1906, and an ingenious arrangement known as the *Septic Tank Latrine*, which consists of a latrine built actually on the roof of a septic

tank, has been introduced. These latrine arrangements are particularly useful for mills, jails, schools, etc.

In this system the combined process depending upon the two groups of organisms, *viz.*, *anaerobic liquefaction* and *aerobic nitrification* is utilised for the purification of the sewage. There is therefore a marked line of demarcation. The anaerobic liquefaction takes place in the septic tank proper, while the aerobic nitrification occurs in the contact beds or sprinkling filters. The sewage, flushed by sufficient water, is first led through one end into a rectangular tank or hollow chamber from which light and air are excluded, and the effluent is let out through a discharge pipe at the other end at a point half-way between the scum and the sludge. The tank should be thin and about five or six times as long as it is broad and must be large enough to retain the flow of sewage from 8 to 24 hours. One measuring 60 ft. by 12 ft. by 6 ft. will meet the requirements of about 2000 users per diem with five gallons flush per user. But a tank capacity of twelve to fifteen gallons per user per day gives the best results. In order to prevent pieces of stones, bricks, or hard lumps of fæces from entering the tank proper and thereby interfering with its true septic action, arrangements should be made to separate these by a partition. This will cut off a portion of the tank into a small compartment known as the *grit* or *detritus chamber*, the capacity of which should be about one-eighth of the tank. The connection between this chamber and the septic tank proper, which is also known as the *digestive chamber*, should be at the bottom, through an opening about 12 in. to 18 in., as it has been found that about 95 per cent. of all fæcal masses float in water, and, therefore, cannot enter the tank. The floor of the chamber should have a slope towards the tank with

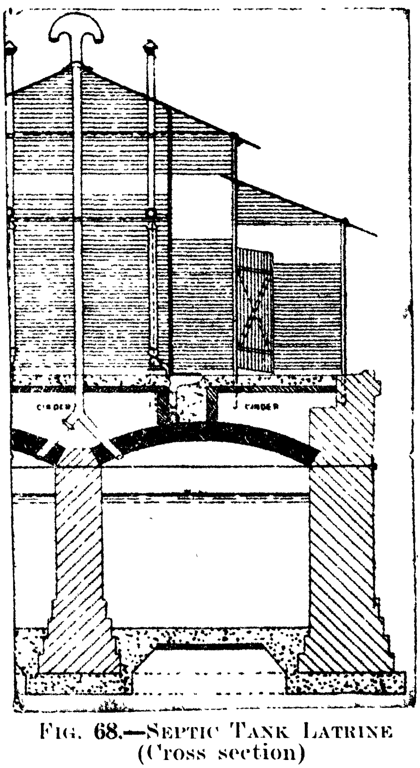

FIG. 68.—SEPTIC TANK LATRINE (Cross section)

a depression in its centre for bricks and other heavy substances to lodge. Ventilation of the tank and the grit chamber should be sufficient and carried on through ventilating shafts, and provision made for inspection and cleansing by means of manholes. When the sewage enters the tank a scum from 2 to 6 inches thick forms on the surface.

Under the scum the *anaerobic bacteria* are actively at work breaking down the solid masses into a state of fine suspension. In the main chamber the process of breaking down the complicated protein molecules into amines, amino-acids, etc., goes on with evolution of gases, mainly methane, carbon monoxide, carbon dioxide, and sulphuretted hydrogen. Colloids in suspension become crystalloids in solution and as such are in a ready condition to take up oxygen. The effluent, which is turbid but translucent, with a sickly but otherwise inoffensive smell is drawn off without disturbing the scum, and as it still holds nitrogen as NH_2 it needs oxygen, and therefore cannot be turned into a stream, as it would take up all the dissolved oxygen. Before discharge the NH_2 should be oxidised to nitrites and nitrates. Therefore it is subjected to further purification in the *contact beds* or *percolating filters* by the aerobic bacteria.

The *aerobic organisms* convert the different ammonia compounds held in solution in the effluent, received from the septic tank, into oxidised nitrogenous substances of a harmless character. These organisms build out of the nitrogenous gases, first nitrous acid, which forms nitrites, and then nitric acid which forms nitrates by uniting with alkaline or other bases. This process is of great importance in biolysis, since these organisms will carry on the purification thoroughly even in the absence of a septic tank, the action of which is merely of a preliminary nature. The best way of getting the effluent into contact with the bacteria is by passing it through *percolating continuous filters* or *contact beds.*

A contact bed is a masonry tank on which the effluent from a septic tank is distributed and allowed to remain for a fixed period, generally two to four hours. During this time the aerobic bacteria adsorb nitrogenous bodies which are converted into nitrates when the air comes in when the bed is emptied. Contact beds are filled up with fine hard furnace clinkers, *jhama*, or gravel ranging in size from $\frac{1}{4}$ to 2 inches. These are not subject to easy disintegration and present a relatively large rough surface for the growth of bacterial masses. They are generally rectangular in shape and may be of any depth, but one with a depth of three feet to four feet gives the best result. The materials should be removed, washed and replaced periodically. It is important that a contact bed should take not more than half an hour to fill or empty itself, otherwise it would be impossible to

arrange the period of rest and contact properly. As in intermittent downward filtration system, the contact bed should be so arranged as will enable each bed after four hours work to have a period of rest for eight hours, in order to establish re-aeration of the bed; otherwise the organisms will die from deprivation of air.

The disadvantage of a contact bed is that it needs an operator.

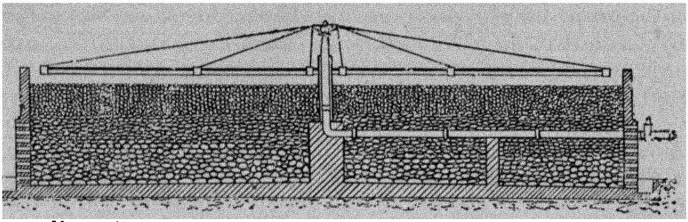

FIG. 69.—SECTION OF A PERCOLATING SEWAGE FILTER.

A *percolating filter* or *streaming filter* operates on the same principle as a contact bed and is used for the same purpose, although the method of application of the clarified sewage is different. These filters are circular or rectangular in shape, usually 6 ft. deep and filled with porous material like *jhama*, cinders, etc., varying in diameter from ¼ in. to 3 inches, scientifically graded from above downwards, over

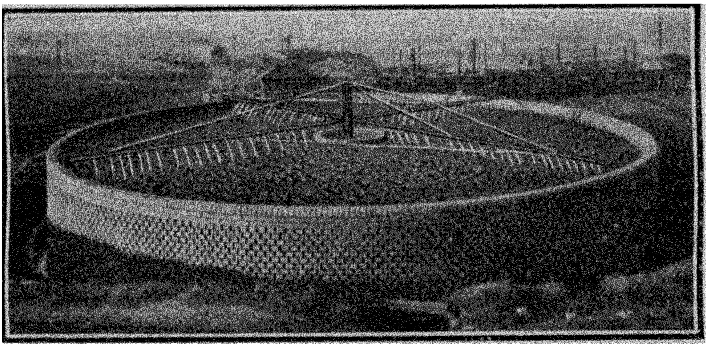

FIG. 70 PERCOLATING SEWAGE FILTER WITH REVOLVING SPRINKLERS

which the effluent is sprinkled through fixed sprinklers, by mechanical travelling sprinklers, dripping trays, tipping troughs, or by revolving sprinkling arms, which revolve horizontally over a circular bed (*see* Fig. 69) to ensure uniform distribution. In passing through the filter the sewage rapidly coats the filtering medium with a gelatinous bacterial growth, and it is by coming into contact with this growth that the organic matter is adsorbed from the sewage so that a

purified effluent results. This adsorbed material is then oxidised by the air in the interstices of the filter so that the gelatinous film is capable of adsorbing further quantities of organic matter. From time to time portions of the film break away from the filtering medium and are discharged with the effluent, it is therefore necessary to provide sedimentation tanks for separating the "humus" from the purified effluent.

When properly designed and started these filters practically require no attention, but their surfaces require to be scraped once a month. It is cheaper, more efficient and requires less attention than a contact bed.

In some installations an open tank has been substituted for a closed one, on the assumption that the tough scum which forms in the septic tank on the surface of the sewage will also form in an open tank, which will prevent the entrance of light and air and will act as a roof for the tank. In practice it has been found to work satisfactorily and, therefore, this modification has been adopted in Manchester. But a closed type of septic tank is preferable to an open one in the tropics, where an open tank will form a breeding place for flies. Moreover the scum is always liable to be damaged and disturbed by wind and rain. The nuisance is often considerable owing to the offensive smell given off from the exposure of the sewage.

The septic tank effluent is generally discharged into a river or stream. But whether it is safe to do so depends upon the size of the river and the amount of dilution the effluent undergoes. It can, however, be satisfactorily disposed of by discharging it on land or into the sea, or by using it for boilers in mills and factories. It has been found that the septic tank effluent contained the eggs and larvæ of hookworm. Tanks that were overworked and filled with sludge showed more larvæ than those that were in proper use. Therefore, where the effluent is discharged into a stream or a river, it is necessary to remove the danger of transmitting water-borne diseases by disinfecting it before being so discharged. This is done by using a definite amount of chloride of lime in solution, or chlorine gas, or by electrolytic action. Chlorine is now applied to crude sewage in order to delay the setting in of septic conditions with resultant smells.

The following are the requirements of a septic tank installation :—

1. There must be an abundant supply of water to provide an automatic or occasional flush, sufficient to carry the excrement to the tank, and also to keep the place clean.

2. Under no circumstances should any disinfectants be used ; this method takes advantage of the biological action of putrefactive bacteria.

3. The tank should be built in two sections under the names of grit chamber and digestive chamber, separated by an upper and lower baffle wall.

4. There must be plenty of space above the line of the

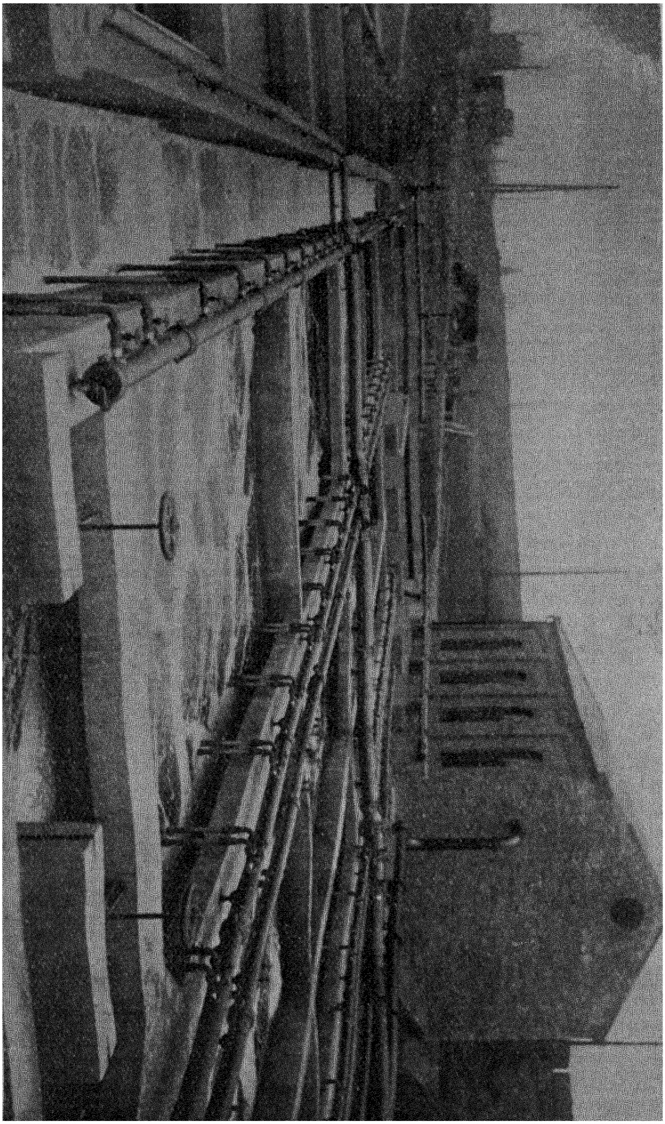

Fig. 71.—View of Activated Sludge Plant showing Aeration Channels and Diffusers

fluid which stands in the tank to accommodate the "scum" and the gas.

5. There must be water-seal inlet and outlet to maintain the fluid at a definite level and prevent the escape of foul gas, which should be let off by a gas pipe and can be burnt in a mantle. This gets rid of all noxious smells and at the same time lights up the place.

When *starting a new tank* it should be inoculated with about a hundred gallons of sludge and effluent from a neighbouring tank and then filled with water. The work of the tank should be pushed on gradually, and it takes on an average about six months to give a satisfactory effluent.

Activated Sludge (Bio-aeration) Process.—This process is in reality an aerobic method of disposal of sewage and is claimed to be the most satisfactory method yet introduced. In this process so far as sewage purification is concerned, the activated sludge performs the same function as the gelatinous film of bacterial growth in percolating filters, but here a much higher standard of efficiency is aimed at. The sewage is mixed with activated sludge and aerated for a definite period which is usually six to eight hours, depending upon the degree of purification required, though may be as short as two hours or as long as twenty-four hours. The sludge is then separated from the purified effluent and may be used again, or may have to be regenerated before it is capable of purifying a further quantity of sewage.

The activated sludge is prepared from ordinary sewage in the aerating tanks in the bottom of which are "diffusers" through which compressed air is passed and atomised for a period of four hours in the proportion of 1.75 cubic feet of air per gallon of sewage so that it rises in minute bubbles through the sewage. This is continued until all the ammonia in the sewage is oxidised into nitrates. The air is then turned off and the sludge sinks to the bottom. The supernatant water is drawn off and fresh sewage may be added. After the process has been repeated several times an accumulation of "activated" sludge results which though resembles septic tank sludge is essentially different from it as it is inoffensive and is an aerobic "bacterial culture" and may be used in the purification process.

The process of purification takes place in two stages. During the first stage the organic matter is broken down and the carbon is converted into CO_2. After this stage the liquid becomes more or less stable, but the process of aeration is continued for a time, when during the second stage nitrates are formed. The working is as follows:—

All heavy grit and large floating solids are first removed and the sewage is passed through a rough screen to the circular tank, where the disintegration is effected by blowing through the sewage minute bubbles of air. This is done

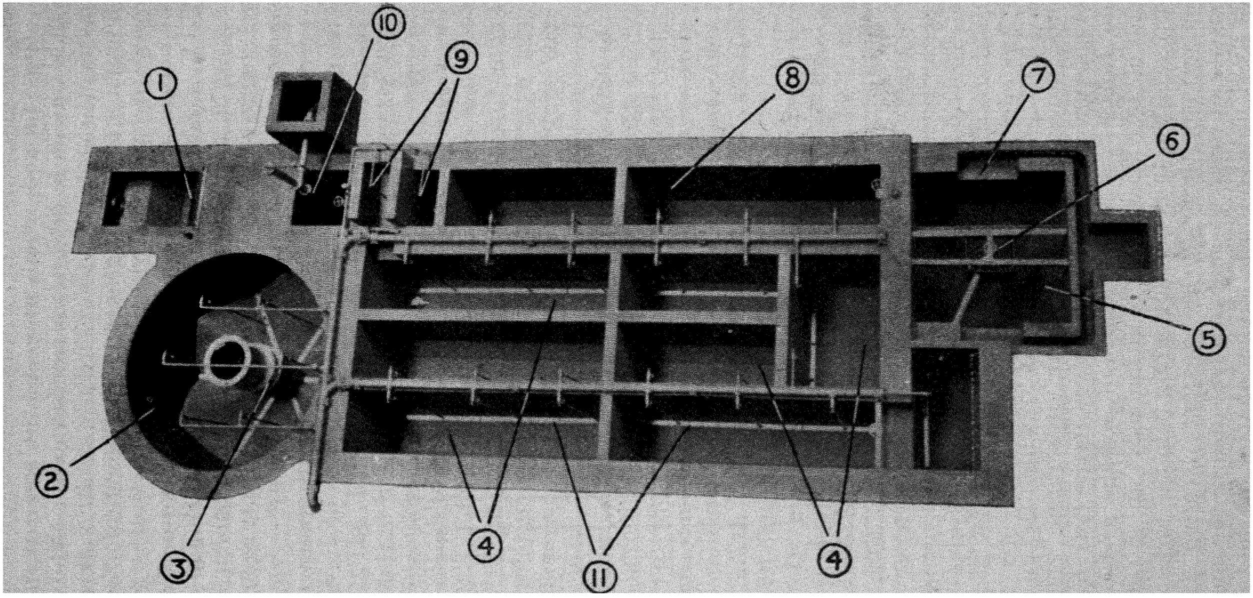

Fig. 72.—Activated Sludge Plant. (1) Coarse screen. (2) Disintegrating tank for breaking up solid matter which is aerated by means of diffusers. (3) A fine screen through which the liquid passes to the aeration channels. (4) The aeration tank. (5) Settlement tank of the inverted pyramid type in which the separation of the mixed liquor into effluent and activated sludge takes place. (6) "Clifford" Inlet through which the mixed liquor enters the settlement tank. (7) Weirs over which the final effluent is discharged. (8) The reactivation channel into which the activated sludge is discharged for reconditioning. (9) Air Lifts for raising the reconditioned sludge. (10) An arrangement with air lift pump for discharging surplus sludge to sludge drying beds. (11) The diffusers.

by porous diffusers fixed at the bottom of the tank in narrow furrows placed radially. A fine emulsion of air and water is thus formed which rises to the top carrying with it the solids which are broken up mechanically. The sewage now passes through the fine screen into the grease-collecting chamber where any grease is collected at the top of the liquid and trapped, while the sewage itself is drawn off from the bottom and is passed into the mixing chamber. Here it is mixed with previously aerated sludge and further aerated by means of the diffusers. The volume of the activated sludge added varies from 15 to 16 p.c. according to the character of the effluent desired.

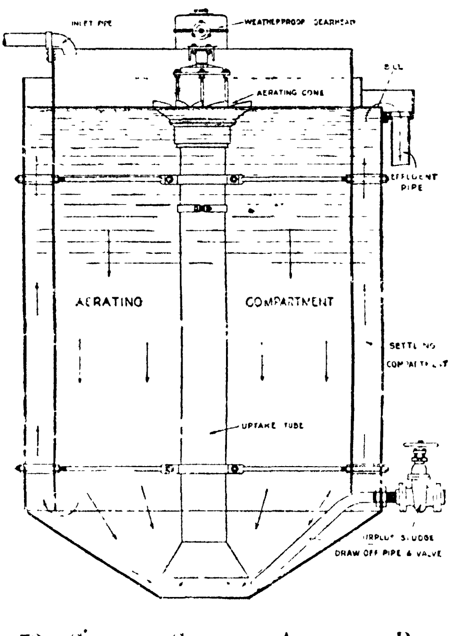

FIG. 73.—SIMPLEX SURFACE AERATION PROCESS.

There are several methods by which the mixture of activated sludge and sewage can be aerated. The air may be blown through porous tiles fitted in the bottom of the aeration tanks ; or the mixture of sewage and sludge may be aerated by drawing it continuously up a tube from the bottom of the tank and spreading it in the form of spray over the surface, the *Simplex Surface Aeration Process.* This consists of inverted cone-shaped tanks in the centre of which are fixed uptake tubes, hopper-shaped on the top and which terminate to about six inches from the bottom of the tank. The top of these tubes contains a cone fitted with vanes and

mounted on a vertical shaft. The cones revolve at a high speed by a motor and suck up the tube a mixture of sewage and sludge and throw it out at the top in the form of a fine spray, breaking up the surface of the sewage in the tank and thus bringing it into intimate contact with the air. A continuous circulation is thus set up, sewage and sludge rising up the tube and descending slowly through the body of the tank. The final separation of the activated sludge from purified effluent is effected in sedimentation tanks which are of the upward flow type provided with conical or pyramidal bottom, but flat-bottomed tanks fitted with mechanical scrapers are largely used now.

Sludge Disposal.—All methods of sewage disposal except broad irrigation result in the formation of large quantities of sewage sludge, and the great difficulty in the activated sludge process is the disposal of the enormous quantities of sludge which contain a very large proportion of water (98 to 99.5 p.c.). Spreading on the land, ploughing in, drying on sludge beds, deep trenching, treatment for the recovery of the grease, artificial drying for use as a fertiliser may be tried according as the circumstances will permit to suit local conditions. Formation of "compost" from the sewage has been tried in Mysore and Indore (*see* page 234). Since the sludge is rich in nitrogen and phosphates, it could be utilised as a valuable manure, provided the water could be got rid of. The sludge is therefore de-watered by air-drying on sand-beds, filtering, centrifuging floatation and spraying. All these methods have been tried in the United States. At Jamsedpur about fifty acres of barren sandy land have been brought under luxuriant cultivation by irrigation with activated sludge effluent and liquid sludge.

Sludge Digestion.—The fact that sewage sludge ferments under anaerobic conditions with the production of large quantities of gas has been known since Cameron in 1896 did his first experiments with septic tanks, but it is only lately that the optium conditions under which this fermentation takes place have been closely studied. Under conditions of favourable fermentation two objects are achieved. The sludge is reduced in amount and loses its objectionable smell, while at the same time it is more easily dried and handled than activated sludge. The gas obtained has a high calorific value and can be utilised for lighting or heating and power production. At first the anaerobic organisms produce an acid fermentation which is objectionable, but later on alkaline fermentation sets in and is maintained.

The fermentation consists of two stages, first a production of gas and later biological changes without gas production. In the first process the sludge is rendered less colloidal and a large amount of water separates which can be removed, thus reducing the bulk of the sludge and allowing the second stage to be carried out in smaller tanks.

The gas obtained consists largely of methane (CH_4) 76 to 85 per cent., carbon dioxide 9 to 30 per cent., nitrogen 1 to 7 per cent., with traces of hydrogen and oxygen. It has been found that the optimum conditions of digestion are obtained if the *p*H of the sludge is kept between 6.8 and 7.6 and at a temperature about 84°C. From 20 to 30 days are usually necessary for complete digestion.

The digestion may be carried out either in Imhoff or Emscher double storeyed tanks or in simple round or rectangular tanks. The gas is collected in floating containers and may be used to heat the sludge digestion tanks. In India sludge digestion has been carried out at Bhatpara and at Titaghar in Bengal by the Public Health Department. The caloric value of the gas collected has been found to be 805.4 B.T.U. per cubic foot as compared with Calcutta gas of 560 B.T.U. The gas at Bhatpara is utilised for driving one of the pumping engines. The rate of gas production in Bengal does not seem to vary much with season.

As a result of experiments carried out at Nagpur (Central Provinces) where sewage of about one million gallons per day for a population of 155,000 had to be dealt with, it has been found that the effluents from the activated sludge and the simplex processes were clear, inoffensive and non-putrescible as compared to the effluent of the septic tank. The simplex process gave better results when the sludge was re-aerated either by the simplex or the activated sludge mechanisms. These led to the conclusion that the bio-aeration processes were superior to the septic tank plus irrigation system. Recently Stewart and Ghosal working at the All-India Institute of Hygiene showed that typhoid and cholera organisms were definitely destroyed by the activated sludge process with a reduction in the number of the intestinal *B. coli*, showing a striking contrast to the usual treatment of sewage by septic tank, trickling filters, etc.

The following are the advantages of this process :—

1. The effluent is fully oxidised and is clear and free from colloids. Purification is rapid and perfect.

2. Putrefaction is quickly stopped and the system is free from smell and flies.

3. The sludge is inoffensive and forms a valuable manure.

4. A small area of land is sufficient, and a skilled attendant with a small staff can easily manage the work.

5. Owing to the simplicity of the plant, the small tank area required, and the absence of filter beds, the capital expenditure is much less.

In India an Activated Sludge Plant has been in operation at Jamsedpur. It is designed to purify 150,000 gallons of sewage daily, derived from a population of 3000 to 4000 people, with very satisfactory results. Another plant has been installed at the Bengal Engineering College.

Two other methods have been advocated of late for the biological disposal of sewage adapted for use in the private houses. They are (1) *The Aqua Privy*, and (2) *The 'Antipolo' System* used in the Philippine Islands. The "aqua privy" consists of a cylindrical tank having a drowned outlet, and a separate upper piece with which is embodied the seat or foot rests. The tank is filled with water before use and the night-soil goes straight into the tank (under the privy seat) where septic action takes place. It is claimed that this system is superior to the ordinary service privy and the chances of infection from water-borne diseases are greatly minimised. The "Antipolo" system consists of a covered pit, a platform or seat with a pipe connected to the pit, and a ventilating tube. It resembles *bored-hole latrine* in construction (*see* page 241) except that a ventilating pipe from the pit through the platform is fixed which should be protected by wire gauze and carried a few feet above the neighbouring houses. It should not be constructed within 100 to 150 feet of a well or a tank the water of which is used for drinking purposes.

Merits of the Different Methods of Sewage Disposal.—Speedy and complete removal of all excremental matters from the neighbourhood of habitations is the primary object to be aimed at. The dry method is not efficient, as the removal of excreta is undertaken at intervals, and it does not satisfy all the requirements. For large towns the water-carriage system is the only efficient method of removal of night-soil. It should not be discharged into any river or stream, but where suitable land is available either intermittent filtration or sewage farming may be undertaken. By land filtration an effluent is usually obtained which may be discharged into a stream, the water of which is not used for drinking purposes. Irrigation, besides giving the above-mentioned results, has the advantage of rendering the land more fertile by holding up certain ingredients having some manurial value. Where land is not available the sewage should be treated biologically. This is by far the best method, as it is based on a solid scientific principle, besides being thoroughly efficient and economical. But the effluent obtained by this treatment is not, as a rule, harmless and therefore cannot be permitted to run into any water-course without subjecting it to a land or special sand filtration, or chemical treatment.

Characters of a good Sewage Effluent.—A good sewage effluent should possess the following characters :—

1. It should have no fæcal smell, and small living fish when kept in it should not readily die.
2. There should be no marked deposit.
3. The amount of organic ammonia present should not exceed 0.1 part per 100,000.

4. The amount of oxygen absorbed in 4 hours at 80°F. should not be more than 1.5 parts per 100,000.

5. The amount of suspended matters should not be more than 3 parts per 100,000.

6. When incubated in a closed bottle for a week at 80°F. it should not show any sign of putrefaction (as evidenced by the production of gases, foul smell, etc.).

CALCUTTA MUNICIPAL ACT OF 1923

Schedule XV

Drains

2. Every underground house-drain shall consist of good sound pipes made of glazed stoneware or other suitable material, and shall have water-tight joints made of Portland cement or any other cement.

3. Every such house-drain shall be of adequate size, with an internal diameter of not less than—

(*a*) six inches between the master-trap and the sewer, and

(*b*) four inches at all other places.

4. No such house-drain shall be so constructed as to form in any of such drains a right-angled junction, either vertical or herizontal, and every branch drain or tributary drain shall be joined to another drain obliquely, at an angle of not less than one hundred and thirty-five degrees, in the direction of the flow of such other drain.

5. Every such house-drain shall be—

(*a*) laid upon a bed of good concrete of such width as may be approved by the Executive Officer, and not less than six inches thick,

(*b*) covered for half its depth with concrete not less than four inches thick, and

(*c*) so constructed as to have a proper fall.

7. (1) In every such house-drain a suitable trap shall be provided.

(2) Such trap shall be placed—

(*a*) within the premises, or,

(*b*) with the approval of the Corporation and on payment of such fees as may be prescribed by the Corporation, in the footpath or (if there is no footpath) in the roadway adjacent to the premises, and

(*c*) at a point as distant as may be practicable from the premises and as near as may be practicable to the point at which the drain is connected with a municipal sewer.

9. The soil pipe of every connected-privy or connected urinal shall—

(*a*) be at least four inches in diameter,

(*b*) be fixed outside the privy or urinal, or outside the building in which the privy or urinal is situated, and be continued upwards without any diminution of its diameter,

(*c*) be of such height and be so placed as to afford, by means of the open end of the pipe, a safe outlet for sewer air,

(*d*) whenever practicable, be so constructed as to avoid any bend or angle, and

(*e*) be so constructed as to have no trap between the pipe and the drains with which the privy or urinal communicates, and no trap (other than such trap as necessarily forms part of the apparatus of the privy or urinal) in any part of the pipe.

11. (1) The following pipes in any new building, namely :—

(*a*) the waste-pipe from any bath-sink (not being a slop-sink constructed or adapted to be used for receiving sewage) or lavatory,

(*b*) the overflow-pipe from any cistern or from any safe under a bath or connected-privy or connected-urinal, and

(*c*) every other pipe for carrying off waste water, shall be taken through an external wall of the building, may, if the Executive Officer

so directs, be provided with a suitable trap, and shall be so constructed as to discharge into the open air over a channel leading to a trapped gully-grating at least eighteen inches distant from that end of the pipe from which the water issues.

17. Except with the written permission of the Corporation and in conformity with such conditions as may be prescribed by the Corporation, either generally or specially, in this behalf, no drain shall be so constructed as to pass beneath any part of a building.

18. The following provisions shall be observed when any drain is, with the permission of the Corporation granted under rule 17, constructed so as to pass beneath a building, namely :—

(1) the drain-pipe shall be of iron or such other material as the Executive Officer may approve ;

(2) the drain shall be so laid as to leave, between the top of the drain at its highest point and the surface of the ground beneath the building, a distance of not less than the full diameter of the drain ;

(3) the drain shall be laid in a direct line throughout the whole distance beneath the building ;

(4) the drain shall be completely embedded in, and covered with, good and solid concrete at least six inches thick all round ;

(5) adequate means for ventilating the drain shall be provided (where necessary) at each end of such portion thereof as lies beneath the building.

PRIVIES AND URINALS

20. The Corporation may, for reasons to be recorded by them in writing and furnished to the applicant free of charge, refuse to grant permission to erect any service-privy or service-urinal which will, in their opinion, be a nuisance.

21. (1) No service-privy or service-urinal exceeding 11 ft. in height shall be placed in the space required by this Act to be left at the back of the building—

(2) No service-privy or service-urinal situated in, or adjacent to, a building shall be placed at a distance of less than six feet from—

(i) any public building, or

(ii) any building which is, or likely to be, used as a dwelling place, or as a place in which any person is or is intended to be, employed in any manufacture, trade or business.

22. (1) No service-privy or service-urinal shall be placed on any upper floor of the building.

(2) The Corporation may, by written notice, require the owner of any building to convert any service-privy into a connected-privy.

23. (1) If there is no convenient access from a street to any service-privy or service-urinal, and if the Corporation consider it inexpedient to require that the privy or urinal be converted to a connected privy or connected-urinal, as the case may be, if they think fit, by written notice, require the owner of the privy or urinal to form a passage giving access thereto from a street.

(2) Every notice served under sub-rule (1) shall require that such passage be formed at ground level, be not less than four feet wide, and be provided with a suitable door, and shall inform the said owner that the passage may, at his option, be either open to the sky or covered in.

25. (1) A drain shall be provided for every service-privy and every service-urinal ;

(2) such drain shall be constructed of some impervious material and shall connect the floor of the privy or urinal,—

(*a*) with a drain communicating with a municipal sewer, or

(*b*) if permitted by the Corporation, with an impervious cesspool the contents of which can be removed to a municipal sewer either by hand or by flow after filtration.

26. (1) The floor of every privy and every urinal shall,—

(*a*) be made of one of the following materials, that is to say, glazed tiles, artificial stone or cement, or

(*b*) if no such direction is given, be made of thoroughly well-burnt earthen tiles or bricks plastered with cement and not merely pointed with cement, and

(*c*) be in every part at a height not less than six inches above the level of the surface of the ground adjoining the privy or urinal.

27. The walls and the roof (if any) of every privy or urinal shall be made of such materials as may be approved by the Corporation: provided that

(*a*) in the case of service-privies and service-urinals, the entire surface of the walls below the platform shall either be rendered in cement or to be made as prescribed in clause (*a*) or (*b*) of rule 26;

(*b*) in the case of connected-privies and connected urinals the walls shall, up to height of at least twelve inches above the platform be made as prescribed in clause (*a*) or (*b*) of rule 26.

28. The platform of every privy and every urinal shall either be plastered with cement or be made of some water-tight non-absorbent material.

29. Every privy and every urinal situated in, or adjacent to, a building shall have an opening, of not less than three square feet in area, in one of the walls of the privy or urinal, as near the top of the wall as is practicable and communicating directly with open air.

30. (1) Every service-privy and service-urinal shall be provided with a movable receptacle for sewage.

(2) The following provisions shall have effect with regard to such privies, urinals and receptacles, namely:

(*a*) the space beneath the platform of the privy or urinal shall be of such dimensions as to admit of a movable receptacle for sewage, of a capacity not exceeding two cubic feet, being placed and fitted beneath the platform in such manner and position as will effectively prevent the deposit, otherwise than in such receptacle, of any sewage falling or thrown through the aperture in the platform;

(*b*) the privy or urinal shall be so constructed as to afford adequate access to the said space for the purpose of cleansing it and of placing therein, and removing therefrom, proper receptacle for sewage;

(*c*) the receptacle shall be water-tight, and shall be made of metal, well-tarred earthenware or glazed stoneware, and of such construction and shape as the Executive Officer may consider suitable;

(*d*) the door of the opening for the insertion and removal of the said receptacle shall be so made as completely to cover the said opening.

31. Every connected privy and connected urinal situated in a building shall be separated by a masonry wall from all kitchens, habitable rooms and rooms in which any person is, or is intended to be, employed in any manufacture, trade or business.

32. (1) Every connected-privy shall be provided with a suitable water-cistern, so arranged as—

(*a*) to discharge direct into the pan of the privy not less than three gallons of water each time the cistern is used, and (*b*) to prevent water being drawn from the cistern for any other purpose.

(2) All waste pipes and overflow-pipes attached to such cisterns shall terminate in the open air and be cut off from all direct communication with any drain.

34. Every connected privy and connected-urinal shall be provided with an air-tight water-trap immediately below the pan.

35. (1) Every connected-privy and connected urinal shall be provided with a siphon-trap which shall be proof against siphonage.

36. No 'container' or other similar fittings shall be placed under the pan of a connected-privy or connected-urinal; and no trap of the kind known as "D-trap" shall be used with any such privy or urinal.

37. (1) Every connected-privy and connected-urinal shall be provided with a soil-pipe for carrying sewage to a municipal sewer.

(3) Such soil-pipe must have air-tight joints, and, if it be placed above ground, shall be made of metal approved by the Executive Officer.

(3) Such soil-pipe shall have in addition to the trap prescribed by rule 34, a trap placed at some point between the privy or urinal and the sewer.

(4) Such soil-pipe shall be ventilated by direct communication with the open air, and if the privy or urinal is situated in a building, the pipe must be carried outside the building.

THE BENGAL MUNICIPAL ACT, 1932

Removal of sewage, rubbish and offensive matter

246. The Commissioners at a meeting shall provide for the removal—(*a*) of sewage, rubbish and offensive matter from all public latrines, urinals and drains, and from all public streets and all other property vested in the Commissioners, and, (*b*) in any municipality wherein a conservancy-rate has been imposed under section 123, of sewage and offensive matter from all private latrines, urinals and cess-pools, and for the disposal of such sewage, rubbish or offensive matter and for the cleansing of such latrines, urinals, drains and cess-pools, and shall maintain sufficient establishment, animals, carts, sewers, pumps, drains, outfall and disposal works and implements for the said purposes.

248. The Commissioners at a meeting may from time to time publish an order prescribing the hours within which and the manner in which sewage, rubbish and offensive matter may be removed.

250. In any municipality wherein a conservancy-rate has not been imposed, the Commissioners at a meeting may provide places convenient for the deposit of sewage, rubbish and offensive matter and may require the occupiers of houses to cause the same to be deposited daily or at other stated intervals in such places, and may remove the same at the expense of the occupier from any house, if the occupier thereof fails to do so as required by this section.

251. (1) The Commissioners at a meeting may from time to time publish an order prescribing the hours within which only an occupier of any house or land may place rubbish or offensive matter on the public street adjacent to his house or land in a proper receptacle provided by the Commissioners in order that such rubbish or offensive matter may be removed by the servants of Commissioners.

(2) No person shall place or allow his servant to place rubbish or offensive matter on a public street at other than the times appointed and except in the receptacles provided by the Commissioners under sub-section (1).

253. No person who, being the occupier of a house in or near a public street, shall keep or allow to be kept, for more than twenty-four hours, or for more than such shorter time as may be fixed by the Commissioners at a meeting, otherwise than in some proper receptacle, any dirt, dung, bones, ashes, nightsoil or filth or any noxious or offensive matter in or upon such house, or in any outhouse, yard or ground attached to and occupied with such house, nor shall any person suffer such receptacle to be in a filthy or noxious state, or neglect to employ proper means to cleanse the same.

254. No person shall—(*i*) throw or put or cause or permit to be thrown or put, any sewage or offensive matter upon any street, or drop, pass or place, or cause to be dropped, passed or placed, into or in any drain, any brick, stones, earth or ashes or any substance or matter, by which or by reason of the amount of which such drain is likely to be obstructed; or

(*ii*) without the permission of the Commissioners pass, or permit

or cause to be passed, into any drain provided for a particular purpose any matter or liquid for the conveyance of which such drain was not provided; or

(iii) without the permission of the Commissioners cause or suffer to be discharged into any drain from any factory, bakehouse, distillery, workshop or work place, or from any building or place in which steam, water or mechanical power is employed, any hot water, steam or fumes, or any liquid which would prejudicially affect the drain or the disposal by sale or otherwise of the sewage conveyed along the drain, or which would, from its temperature or otherwise, be likely to create a nuisance.

257. The Commissioners shall provide and maintain in sufficient numbers and in proper situations public latrines and urinals for the separate use of each sex, and shall cause the same to be kept in proper order and to be properly cleansed.

258. (1) When application is made to erect or materially alter any building—(*i*) intended for human habitation, or (*ii*) at or in which labourers or workmen are to be employed, the Commissioners may direct that such privy and urinal accommodation shall be provided as they consider to be suitable therefor.

(2) In directing the provision of any such accommodation the Commissioners may determine in each case—(*a*) where an underground sewerage system has been provided, whether such building shall be provided with service or connected privies or urinals, or partly with one and partly with the other; and (*b*) what shall be the site or position of each privy or urinal, and their number.

(3) When any premises at or in which not less than twenty labourers or workmen are employed are without privy, urinal, bathing or washing place accommodation to the satisfaction of the Commissioners they may, by written notice, require the owner of such premises to provide such privy, urinal or bathing or washing place accommodation as they may prescribe.

261. No person shall, without the written permission construct or keep any house-drain, service-privy, urinal or cess-pool within fifty feet of any tank, well or water-course or any reservoir for the storage of water or construct any privy with a door or trap-door opening into any road or drain.

262. (1) All latrines, urinals, sinks, cess-pools and drains shall be subject to the control of the Commissioners and the Commissioners or any officer authorized by them in this behalf may inspect any latrine, urinal, cess-pool, sink, drain or receptacle for sewage or offensive matter at any time between sunrise and sunset.

263. (1) The Commissioners may require by notice the owner or occupier of any land or building, within a period to be specified in the notice,—*(a)* to close, remove, alter, repair, disinfect or put in good order any cess-pool, drain or receptacle for sewage, offensive matter or rubbish pertaining to such land or building, to provide to their satisfaction access from a house-gully or lane to any service-privy or service-urinal in or on such land or building, or to demolish any privy or urinal constructed, rebuilt or altered in or on such land or building in contravention of section 261 or any by-law framed under section 269 or section 277: (*b*) to provide such cess-pools, drains or receptacles for sewage, offensive matter or rubbish, as should, in their opinion, be provided for the building or land whether in addition or not to any existing ones; or (*c*) to cause any latrine or urinal provided for the building or land to be shut off by a sufficient roof and wall or fence from the view of persons passing by or dwelling in the neighbourhood.

264. (1) Where a privy or privies belonging to one or more premises are so placed as in the opinion of the Commissioners to afford to the municipal conservancy staff no suitable means of access thereto for the purpose of cleansing such privies, the Commissioners may.

by written notice to the owner or owners of such privy or privies, require them to provide a house-gully of such dimensions and so paved and drained as they may think necessary for such purpose.

(2) If such notice be not complied with within the time fixed by the Commissioners, they may themselves acquire land and construct such house-gully, and the expenses thereby incurred shall be paid by the owner in default, and where there is more than one owner, by the owners in such proportion as may be settled—(*a*) by the Commissioners at a meeting; or (*b*) in case of dispute, the District Magistrate.

265. When, under sub-section (1) of section 263, an owner or occupier is required by the Commissioners to use disinfectants the Commissioners may themselves supply disinfectants or deodorants for such use at cost price, and the expense thereby incurred shall be considered as an arrear of tax, and be recoverable as such from the owner of the cess-pool, drain or receptacle, as the case may be, or the Commissioners at a meeting may, if they think fit, order that such expense shall be paid from the Municipal Fund.

266. The owner or occupier of any premises to which any latrine, urinal, cess-pool, drain or other receptacle for sewage or offensive matter pertains, shall keep in a proper state such latrine, urinal, cess-pool, drain or other receptacle.

CHAPTER XIV

DISPOSAL OF THE DEAD

STRANGE indeed are many of the ceremonies attending the disposal of the dead in different parts of the world, and following the natural order of things, the more primitive the nation the more primitive its methods. The rudest mode now prevalent is that of simply leaving the body exposed, but the ways of exposure vary considerably. The Wanyamwesis, in West Africa, carry their dead into the forests to be devoured by beasts of prey, while some of the tribes of Guinea throw the corpse into the sea. The Kamtchadales keep dogs to consume their dead. The Thibetans cut up their dead and feed vultures and dogs, while the Parsees place their dead in a round tower, called the Tower of Silence.

As knowledge grew so the desire to preserve the dead increased and everything was done to prevent or hinder the return of the body to its constituent parts. So embalming, the heavy lead coffin, the sealed stone sarcophagus were all used in turn. But the burning of human remains has been practised throughout the world from remote antiquity, though it has not been considered to be an acceptable method yet in many countries.

When it is realised that several millions die every year in India and of these quite a large number from infectious diseases like smallpox, cholera, etc., it will be at once apparent that safe disposal of the dead in such a manner as not to affect the public health is an important sanitary problem. Customs associated with its disposal are too well established. Any modification, therefore, in the direction of improvement should be made "having due regard to the sentiment of the relations and the populace generally and to the religious observances peculiar to each sect." The method of removal of the dead for disposal is no less important. The usual practice in India is to carry the body on a *charpoy* or a small wooden bed . but with certain poor classes it is often carried tied on to a length of bamboo. Moreover, the bodies are not always properly covered. Such a practice is not only unsightly but unhygienic.

Although the spread of infection from the dead body of any infectious disease is not so great, yet there is no doubt of the possibility of the spread of infection in the case of smallpox or cholera. In the former the whole body is covered with infective material, while in the case of the latter the body surface and the clothing become infected with the discharges. It is therefore of great importance that

these bodies should be covered with cloth soaked in some antiseptic lotion.

CREMATION OR BURNING

Cremation may be said to have been the general practice of the ancient world, with the exception of Egypt, where the bodies were embalmed; Judæa, where they were buried in sepulchres; and China, where they were buried in the earth. Cremation is the most satisfactory method of disposal of the dead, and is the old-established custom with the majority of the Hindus, who burn the body on a pyre in the open air. By this method the body is reduced to a small quantity of odourless ash within about three hours. The bodies are cremated on the bank of rivers, and in the absence of a river, on the bank of some tank. The usual fuel is wood (ordinary *soondry or goran*), and costs about six rupees (ten shillings). The quantity of fuel required to completely consume the corpse of an adult is about five maunds or 400 lbs. The bodies are as a rule so covered with wood that very little can be seen. The smell is hardly perceptible at a short distance, and if the place is enclosed by a wall the nuisance to the neighbourhood is reduced to a minimum. Unfortunately however burning as practised in this country especially by the poorer classes leaves much room for improvement both on sanitary and æsthetic consideration. Fuel being expensive the bodies are not often properly burnt and the half charred bodies are often thrown into the river or stream.

In large cities cremation acquires an increased importance on account of the promptitude with which dead bodies may be disposed of during epidemics, as fire removes all traces of contagion that might remain in a grave-yard. A burning ground also occupies less space. The smoke and smell coming from a burning ground, especially when it is in full action, indicate that the temperature of the fire is insufficient and heat is being wasted. An open fire cannot concentrate its heat on a body, and the smoke proves that the air supply is defective. To consume a body rapidly, completely and without offence, the fire should reach its highest temperature before the body is placed in it, and this is only possible when it is enclosed in a properly constructed furnace.

Cremation is gradually becoming popular with Europeans in India and a crematorium has been established in Calcutta. The most perfect cremation furnace should consist of a bed of finely broken quartz, seven feet long and twentyeight inches wide, supplied from beneath with a mixture of gas and air, which when properly adjusted burns without visible flame, rendering the quartz bed nearly white hot. A temperature of 3,000° F. will decompose water to its elements and consume all organic matter. The furnace should be enclosed with an opening above to let out the invisible and odourless products

of combustion. The process will last for about half an hour, and the residue left will be a small quantity of white lime from the bones. A number of these furnaces could be put in a very limited space.

Within recent years many bodies have been exhumed in England, and in some cases the crime has been brought home. It is argued than if these bodies were cremated the criminals would have escaped. The compulsory use of death certificates will to a great extent minimise this. But the time for detecting crime is not after but before the body is disposed of. Poisons like copper, arsenic, etc., might be detected from the ashes or unburnt pieces of wood.

Earth Burial

The object of burial being speedy resolution and complete oxidation, the soil best suited for the purpose is a sandy or calcareous loam. This should be reasonably porous and light, and either naturally or artificially drained to a depth of 8 ft. Clay soil is bad as it cannot be drained properly, and allows the products of putrefaction to escape through cracks in dry weather. The same objection applies to a chalky soil. Burial is a very expensive method of disposing of the dead; besides the initial outlay of purchasing the land there is a recurring expenditure for establishment, structural repairs, etc.

In the selection of a burial ground the following points should be attended to :—

1. Lands liable to flooding are unsuitable.
2. The ground should not be high, as the natural drainage may pollute the water-supply at a lower level.
3. The area should be marked into plots, and provided with pathways at convenient intervals.
4. The area should be outside the limits of future buildings. The ground should not adjoin dwellings, and trees and shrubs should be planted to absorb the carbonic acid given off during the disintegration of the bodies.

Overcrowded cemetries influence the health of the people of the locality prejudicially by (*a*) contamination of the air; (*b*) contamination of the water by products of decomposition; and (*c*) contamination of water-supply by specific organisms.

The number of full-sized non-masonry graves to a cottah (720 sq. ft.) of land allowing 6 ft. by $2^1/_2$ ft. for each, and a space of 4 feet between, would be only twelve, or two hundred and forty to the bigha. If the intermediate spaces could be utilised in future without disturbing the graves, one bigha will altogether accommodate 480 corpses. In Calcutta ordinarily, 7 feet by 4 feet is allotted for full-size non-masonry graves for those above ten years, 5 feet by 3 feet for those of children under ten, and 3 feet by $2^1/_2$ feet for those of infants under one year. The area should be marked out in plots and interments made in regular lines

with pathways at covenient intervals. Deep burial should be avoided, and a space of at least 2 feet should be left between the level of the subsoil water and the dead bodies. In fact for every foot of depth below the soil it takes one year for necessary resolution. The use of metallic or strong wooden coffins, brick graves or vaults helps to preserve the bodies for a long time, and thus interferes with their proper resolution and oxidation. Bodies should be interred in easily destructible coffins, 3 to 5 feet below the surface of the earth, where the micro-organisms exist in abundance. The Mahomedans do not use any coffin therefore the bodies disintegrate more rapidly than when coffins are used. Too shallow a burial should be avoided, as there is risk of the graves being dug up by jackals or other animals, and in all cases they should be protected by strong fencing. It takes about a year for the soft parts to disappear inoffensively.

THE CALCUTTA MUNICIPAL ACT. 1923

Disposal of the dead

457. (1) Every owner or keeper of a place, not vested in or owned by the Corporation or a Board appointed by the Local Government for the administration of such place, which is used for burying, burning or otherwise disposing of the dead shall cause the same to be registered in a register which shall be kept by the Corporation and shall deposit in the municipal office at the time of registration a plan of the said place showing the extent and boundaries thereof and bearing the signature of a surveyor in token of its having been prepared by or under the supervision of such surveyor. (2) All burial and burning grounds shall be classified by the Corporation in the said register as public or private. 459. Except with the written permission of the Corporation—(*a*) no place which has never previously been lawfully used as a place for the disposal of the dead and registered as such shall be opened by any person as such place, and (*b*) no burial or burning ground or other place for the disposal of the dead which has fallen into disuse shall be again used as such. 460. (1) If, the Health Officer is at any time of opinion—(*a*) that any place of public worship is, or is likely to become, injurious to health by reason of the state of the vaults or graves within the walls of, or underneath, such place or in any churchyard or burial ground adjacent thereto, or (*b*) that any other place used for the disposal of the dead is in such a state as to be, or to be likely to become, injurious to health, he may submit his said opinion, for the consideration of the Local Government who shall direct the closing of such place for the disposal of the dead. 462. (1) No person shall, without the written permission of the Executive Officer, —(*a*) make any vault, grave or interment within any wall, or underneath any passage, porch, portico, plinth or verandah, of any place of worship; or (*b*) make any interment or otherwise dispose of any corpse in any place which is closed for the disposal of the dead under section 460; or (*c*) build, dig or cause to be built or dug any grave or vault, or in any way dispose of, or suffer or permit to be disposed of, any corpse at any place which is not registered ; or (*d*) exhume any body from any place for the disposal of the dead, except under the provisions of section 176 of the Code of Criminal Procedure, 1898, or of any other relevant enactment for the time being in force.

CHAPTER XV

PERSONAL HYGIENE

In the preceeding pages we have described the different environmental factors which contribute to the health and well-being of the community in general, *i. e.*, concerned with public health, but which are equally important to the individual, although these have to be handled as an organised activity of the community as a whole. Personal hygiene on the other hand deals with matters pertaining to the health of the individual himself for the maintenance of which the responsibility lies with him alone. Self preservation is a law of nature, but to be able to live a healthy life and keep the body and mind at the best level not only for the sake of health but for the satisfaction of serving the world and society is a blessing only enjoyed by man, and should be the aim and ambition of every person. All men however are not endowed with the same amount of mental efficiency any more than with physical well-being. While one enjoying good physical and mental powers should not only learn to utilise them to his best advantage, he should also recognise the limitations beyond which any attempt to run the human machine will be frought with danger. Similarly one less fortunately endowed should adjust his activities within the limits of his bodily powers and at the same time should try to correct his shortcomings and improve his general condition by following hygienic laws. According to Adler man has three main phases of life, *viz.* occupational, social and sexual. How to find an occupation which will enable us to survive under the natural limitations set by the nature of the earth, how to find a position amongst our fellow brethren so that we may get the benefit of mutual co-operation, and finally how to reconcile ourselves to the fact that we live in two sexes, and that the perpetuation of the species depends upon our sex life. These are the different problems which confront us. It should be the aim of every man to live on a higher plane, and one should not always follow the dictates of instinct. Indeed one has to keep his instinct under control, and moderation in all matters should be the guiding principle. It is however the environment in which the individual is brought up that determines his various instincts and sensations. Apart from the environment the other predominating factor which influences the life of the individual comes from the inward constitution which we call *heredity*.

The question whether environment or heredity plays the

more important part is unsettled, but both are equally essential. Experimental evidence goes to show that what is inherited is something definite and unchangeable for several generations. In fact geneticists are generally agreed that our hereditary equipment includes every resource of the body, mind and spirit. Thus we come to the world with certain potentialities which can be developed up to a certain limit fixed by inheritance.

Heredity and Eugenics

Heredity means the transmission to the descendants of the physical, mental and moral traits and dispositions of the ancestors in varying proportions. Since it is known that heredity plays some part in the transmission of certain diseases, malformations and defects, it will be interesting to study the different experimental observations on which our modern knowledge of heredity is based. The nucleus of the body cells shows pairs of stainable rods of various shapes called *chromosomes*. These pairs are homologous and are of the same shape and size. When the germ cells are formed, the pairs separate, one member of each homologous pair going to each germ cell. The conjunction of two germ cells brings the number of chromosomes up to the normal again. There are in the human body 24 pairs of chromosomes. Twenty-three pairs are of the same size and shape and are known as the *ordinary* or *regular chromosomes*. The remaining pair contains the hereditary substances or characters which determine the sex of the offspring and are known as the *sex chromosomes*. The ordinary chromosomes are carriers of the hereditary substances from the parent to the child and are the vehicles for transmitting physical and mental characters. Some of the characters borne by the chromosomes become conspicuous in the progeny and are *dominant characters*, while others remain undeveloped or *recessive*, *i.e.*, cannot be observed, but may later be transmitted to the progeny of succeeding generations, when they become prominent under certain conditions. The particular part of the chromosome which determines the special type of the character from the parent to the offspring is known as the *gene*. If there is a dominant gene in either of the homologous chromosomes that character appears in the organism, even though there is a recessive gene present in other chromosomes. To bring out a recessive character the recessive genes must appear in *both* members of a pair of homologous chromosomes, *i.e.*, in the germ cells of both parents.

The problem of transmission of hereditary characters was first studied by Mendel in plants. Taking two varieties of peas, one dwarf variety which grows to a height of a few inches, and the other tall variety which reaches a height of

several feet, he crossed them artificially. He found that when the pollen of one variety was used to fertilise the flowers of the other the resulting seeds when grown produced tall plants only. By crossing these tall plants amongst themselves, the seeds resulting therefrom when grown produced both tall and dwarf plants in the proportion of 3 to 1. But the tall plants when allowed to self-fertilise produced two sets of plants. Some produced both tall and dwarf

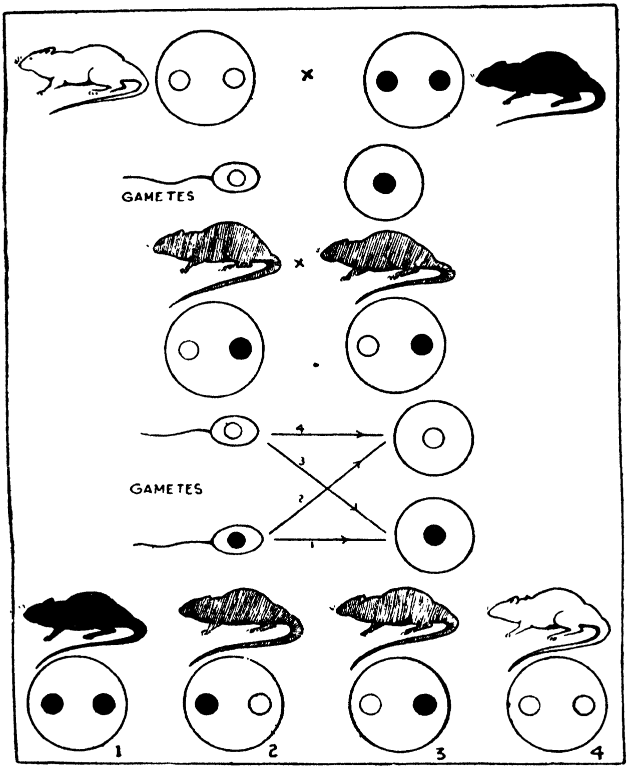

FIG. 74.—The Mendelian explanation of the breeding of white mouse with black mouse. A white mouse with two "white" genes in each nucleus (upper left) is bred with a black mouse with two black genes (upper right). The resulting generation (middle row) have one gene of each kind and are therefore grey. When these are inbred, black, grey and white are produced. Modified from *The Science of Life* by H. G. Wells, Julian Huxley and G. P. Wells.

plants in the proportion of 3 to 1 while others produced tall plants only. It will be observed that the character of tallness dominates in both generations of progeny, and is the *dominant character* while dwarfism is the *recessive character*. Now let us take the case of black and white mice. If we cross these two we get a progeny of grey, a hybrid

generation. If we inbreed these again we get a second generation of three distinct types ; *viz.* black and the white like the original stock, and the grey of the first hybrid generation. It will thus be seen that the units in the constitution which determine black and white were neither lost nor merged together to form grey mice, but remained distinct to be able to come out unchanged in a later generation. These contained the determiners or genes of black and white and these will always breed black and white. These were *pure* or *homozygous, i.e.*, their germ-cells did not possess characters other than pure white or pure black. But the chromosomes of the grey ones contain characters or genes of both black and white, and these will breed black, white and grey. These are *heterozygous, i.e.*, the chromosomes of each cell contains determiners for both black and white.

The hereditary substance which determines the sex or any other character of the offspring is called a *determiner.* Sometimes however a new character occurs which cannot be explained as being due to any specific gene, but is due either to the formation of some new gene arising as a natural process of evolution, or to genes changing their characters from environmental influence. This is known as *mutation*.

According to the Hindu law-giver Manu the wife has been compared to soil and the husband to seed ; of the two the seed is more potent, since no organisms deviate from the characters of the seed. It appears that Manu regarded the female germ as complementary to the male, the function of the former being mainly nutritional and that of the latter of the nature of a determiner.

Many abnormalities or peculiarities are perpetuated through repeated generations of the offspring. Thus harelip, polydactylism, and other congenital defects or deformities can be traced through many generations of the stock. It is believed that there is some positive factor that induces the formation of these deformities.

To the student of preventive medicine the hereditary transmission of disease is of the utmost importance. Notwithstanding the popular conception to the contrary, infectious diseases are not inheritable in the proper sense. No disease germ nor any disease determiner is passed from parent to child through the ovum or spermatozoon. True inheritance is transmitted through the chromosomes of the germ cells and no chromosomes either of the spermatozoa or ova transmit the germs of disease.

Of the diseases generally classed as transmissible are syphilis, hæmophilia, tuberculosis, gout, anaphylaxis, colour blindness, myopia, epilepsy, hereditary ataxia, insanity, etc. Of these the following require more than a passing notice :—

Syphilis.—It is not transmitted hereditarily in the proper

sense. It is really congenital and is acquired before birth by the fœtus. The treponema circulating in the blood stream of the mother apparently penetrate the placenta, and enter the fœtal circulation.

Hæmophilia and Colour Blindness.—Hæmophilia is a condition characterised by the diminished coagulability of the blood so that a minute wound, which to a normal person is of little consequence, causes profuse hæmorrhage. Such persons are called "bleeders." This condition and colour-blindness are passed down from one generation to another through sex-linked inheritance. Hæmophilia is transmitted by normal females mostly to male descendants. Colour-blind fathers transmit the defect not to the children but to one-half of the grandchildren; whereas colour-blind mothers transmit the defect to all her sons and not to the daughters, to one-half of her granddaughters and one-half of her grandsons.

Tuberculosis.—This is not transmitted hereditarily. The reasons why the disease runs in the family are (1) inheritance of low capacity to resist disease; (2) inherited predisposition; and (3) greater opportunities for infection due to close association of the infected with other members of the family.

Mental Disease.—It is generally believed that mental disease is transmitted hereditarily. But this view has been challenged recently and the whole question of heredity and environment in the production of mental defect and disorder was reviewed by a Committee of the Board of Control of England (*British Medical Journal, Jan.* 27, 1934). Although most of the witnesses recognised 'heredity' as an important factor in the causation of mental defect or disorder, the Committee came to the conclusion that except Huntingdon's chorea and myoclonous epilepsy, which were both rare types, there were no conclusive evidence that the transmission of mental defect or disorder followed Mendelian ratios. On the other hand the Committee regards as clearly established that a proportion of cases of mental deficiency is due entirely to environmental factors, although the proportion is comparatively small. The Committee is of opinion that 29 per cent. of mental defect are hereditary, pure and simple, 9 per cent. are due to environmental conditions, and the remaining 62 per cent. are conditioned by both heredity and environment. The incidence of abnormal conditions is definitely greater in the families of the higher-grade defectives than in the families of lower-grade defectives. And the families in which there are mentally defective children have other members, who, though not mentally defective, are persons of low intelligence.

Eugenics.—We have now to consider the question of eugenical application of the laws of inheritance of defects. *Eugenics* is defined as the science of healthy race culture, *i.e.*, of being well-born. According to Deane Inge in the absence of any

systematic race culture we shall gradually slide back into feeble and helpless creatures, the destined prey of some more vigorous stock. According to Blacker it implies the general aim that people should be well-born, and that the function of parenthood should not be left to chance, but should be so planned and directed by the parents as to yield the best results for the future generation. A nation consists of peoples and peoples of races. National culture and progress implies race culture, *i.e.*, to make each man and woman fit physically, mentally and spiritually. What are the factors that make the individual noble or base, healthy or diseased, wise or foolish, clever or stupid, kind or cruel ? Eugenists attribute every character of every living being to the product of nature or nurture. Nature includes everything given at the individual's beginning, nurture includes all nutrition from the moment of the formation of the new individual onward, and includes environment—physical, social and spiritual.

The problem of practical eugenics has three aspects, *viz.* (*a*) how worthy parenthood may be encouraged (positive eugenics) ; (*b*) how unworthy parenthood may be discouraged (negative eugenics) ; and (*c*) how parenthood may be protected from racial poisons. Except in so far as the private judgements of the individuals about to marry are concerned little attempt at positive eugenics has been made. It is often asked why so many people of the well-to-do classes do not have children. It is possible that the following factors are responsible, *viz.*, the man or the woman may be sterile, or the man may be impotent, or the woman may have a history of miscarriages. Both may be averse to have any children, or the child bearing may be dangerous on grounds of health for the woman. In rare instances the married couple may lack parental instinct. Apart from these factors the other causes of fall of birth-rate are the changes in inherited racial constitution, and changes in bodily metabolism which tend to reduce reproductive vigour.* Professor Gini has advanced the theory of the ageing of the race. He considers that a race or a family passes through the stages of youth, maturity and old age, as does an individual. According to him the upper classes are further on " the parabola of evolution " than are the lower, hence their fertility is diminished. How these different diverse factors may be remedied, whether by help of treatment or by changes in our laws or customs is a subject for the positive eugenists. Negative eugenics aims at limiting the fertility of stocks which are regarded as unsound. The methods advocated are birth control, sterilisation, segregation, legal prohibition of marriage, abortion, and euthanasia.

With regard to birth control by the use of contraceptives there is much difference of opinion on the desirability of its

* Hankins, *Eugenics Review*, Vol. 23, 1931

wide application. A method which is simple and reliable and without any harmful effect on the users and æsthetically unobjectionable has yet to be found. In persons exhibiting serious hereditary defects, if descended from a strain that they may be possible carriers of the defect, steps should be taken that there should be no issue to the marriage of such persons. Economic conditions, poverty and ill-health of the parents play an important part in the domestic life of married people. If sexual continence cannot be relied upon for limiting the number of children, birth control measures may be adopted not for absolute prevention of conception but for regulating the intervals, or for spacing the birth of children according as the health of the mother or the family purse will permit. Extensive use of birth control measures may have a harmful effect on the morality of the people. Human nature being what it is there is the possibility of promiscuous sex relations. Moreover the existing methods can only be used by people of intelligence and education, so that after continuous use of these measures for several years there will be the danger of the population degenerating, as there will be more of the ignorant and unwelcome type and less of the intelligent and desirable type who will be an asset to society. The subject is beset with so much possibilities for good or for bad both in the domestic and social life that birth control measures should be introduced very cautiously so that the maximum of good can come out of its use with the minimum of harm.

Segregation of all persons likely to prove dangerous to society including habitual criminals, diseased and defectives has been advocated by the Society of Eugenics. This of course requires legal power and government help.

Sterilisation was performed as a compulsory measure in several American States on various types of mental defectives. One idea was to prevent parenthood and another that many could be released from state expense. These experiments have not proved successful for various reasons and most of the States have now made such sterilisation a voluntary measure. Sterilisation so far as is known has no direct effect, for better or for worse, upon the physical powers or the mental or moral functions. Thus if a moral degenerate be sterilised and let loose in society he night continue these activities. The Committee of the Board of Control above referred to after careful survey concluded that the case for compulsory sterilisation could not be established, although they recommend that voluntary sterilisation be sanctioned by law on the assumption that enough is known to be true that inheritance plays an important part in the causation of mental defects and disorders. The Committee further holds that mentally defective and mentally disordered parents are, as a class, unable to discharge their social and economic

liabilities or create an environment favourable for the upbringing of children. The operations for sterilisation which are recommended are vasectomy in the case of males and salpingectomy in the case of females.

Abortion has also been advocated but its advantage from the eugenic standpoint requires careful study before it can be legalised. Dr. Killick Millard would like to legalise *euthanasia* for persons suffering from lingering, painful and incurable diseases. But this has no eugenic significance, since persons like these rarely reproduce themselves. For humanitarian reasons a child born defective mentally or with other serious defects should not live, but from the eugenic point of view all that is wanted is that it should not reproduce when it grows to maturity if there is any probability of the defect being handed down. This aim may be achieved by sterilisation at a later period of life.

Amongst the Hindus marriage is obligatory to every man and woman for the sake of having children. Inbreeding is prohibited, as it perpetuates the objectionable hereditary characters, and by securing the homozygous combinations brings out the latent or recessive characters in the progeny. In general it has been found that if an animal or plant stock is constantly inbred, its size, its fertility and its economic worth will deteriorate. But if there are harmful recessives, inbreeding will be bad and outbreeding good, on the other hand if there are desirable recessives the reverse will be true. In the case of human stock tainted with a concealed recessive hereditary defect any form of inbreeding will be harmful. The classical example of inbreeding producing actual improvement of the original stock is that shown by Miss King by mating brother and sister of albino rats for generation after generation. The eugenic minded individual will therefore, in the first place, be careful whom he marries, and will give greater weight to such qualities as good health, vitality, intelligence, character and psychological robustness than to wealth or social position.

That the principles of eugenics were practised in India specially by the Hindus is evident from the following teachings :—*Grihya Sutra* says "Let him first examine the family of the intended bride and bridegroom, those who are on the mother's side and on the father's side. Let him marry a girl that shows the characteristics of intelligence, beauty and moral character, and who is free from disease." *Manu* enjoins avoidance of the following kinds of families, *viz.* those in which the usual good practices of life are conspicuous by their absence, in which no male children are born, in which the members are illiterate, very hairy, afflicted with hæmorrhoids, tuberculosis, dyspepsia, epilepsy, white leprosy (leucoderma), and leprosy. Similarly girls with copiously hairy bodies and who possess extra organs or other

abnormalities, or who are invalids, ill-tempered and pugnacious should not be selected.

A summary of the policy of the British Eugenics Society is given below :—

Moral and Scientific Bases.—The moral basis of eugenics is that our duties extend not only to our neighbours, but also to all posterity. The scientific basis is that the offspring of persons above or below the average in any natural quality will probably be respectively above or below that average with regard to this same quality.

Hence, to insure racial progress and prevent racial degeneration it is necessary to advocate a speedy realisation of the following reforms, precautions and changes in social policy, a change in public opinion being a necessary preliminary step.

1. *Definitely Defective Types.*—Prevention of reproduction either by (*a*) *Segregation*, or (*b*) *Sterilisation*. These apply to individuals of unquestionably mentally defective type, habitual criminals, confirmed drunkards, and the chronic unemployables.

2. *Public Opinion as a Safeguard.* This is important to prevent parenthood of the insane after recovery, the epileptic, and those suffering from certain comparatively rare hereditary defects, and in normal persons with a seriously defective family history.

3. *Family Limitation of the "less fit".*—This is applicable to stocks which are generally inferior without presenting clearly recognisable defects.

4. *Superior Stocks.*—The birth rate of the superior types must be made to be at least as high as that of the inferior types. Therefore to limit the family is to encourage national deterioration owing to race-suicide of superior stocks.

5. *Conception Control.* It is justifiable only on the following grounds : (*a*) Recognised medical reasons ; or (*b*) to secure an adequate interval between births ; or (*c*) when the child could not be reared in accordance with a certain minimum standard of civilisation; or (*d*) to avoid lowering the standard already attained by the family: or finally (*e*) on account of the probable transmission of serious hereditary defect.

6. *Selection in Marriage.*—People should realise the disadvantages to themselves and their descendants likely to arise from marriage with the unintelligent and unhealthy.

7. *Legislation in Regard to Marriage.*—As a preliminary to issue of marriage license, declarations regarding convictions for crime, legal certificates regarding mental defects and disorders, previous marriage, sterilisation and freedom from certain diseases should be exchanged between the parties concerned.

8. *Illegitimacy.*—Facilities for obtaining allowances for such children by mothers should be more easy and less troublesome.

9. *Human Stocktaking.*—The mental and physical qualities of the youth should be measured periodically to ascertain if the race is improving or deteriorating,

10. *Education.*—All Universities to undertake research and higher education in regard to human racial questions.

11. *Immigration.*—No alien immigrants shall be admitted who are likely to lower the racial qualities of the national stock.

References.—A. B. C. of Genetics, *The Science of Life* by H.G. Wells ; C. P. Blacker, *Journal of State Medicine, March*, 1934 ; Castle, *Heredity, Genetics and Eugenics* ; East and Jones, *Inbreeding and Outbreeding* ; Eugenics, *Recent Advances in Preventive Medicine*.

The following personal factors conducive to good health may now be considered :—

Habit.—Habit plays an important part in the preservation

of health. It is readily formed, grows by practice, and eventually becomes a part and parcel of nature, making its eradication a matter of great difficulty. It is for this reason that habit is called second nature. The influence of habit in the formation of the character of individuals is known to all, but its influence on the physical and mental condition of men, particularly of children can never be over-estimated Indeed, it is productive of good and abortive of evil. This subject may be discussed under the following heads, which are more or less influenced by habit :

(*a*) *Eating and Drinking.*—A regular habit with regard to eating and drinking is essential for the preservation of health. Food, which must always be wholesome, should be properly masticated and eaten slowly. It is a bad habit to overload the stomach. Alcohol, as a rule, should be avoided and the very fact of craving for it is an indication of ill-health.

The following points should be carefully attended to :—

1. Always wait for a true appetite.
2. Select the food the appetite particularly craves for at the moment.
3. Masticate well.
4. Do not hastily swallow a mouthful, but let it be swallowed as it were by itself.
5. Avoid serious reading during meals.
6. Agreeable society at meal times is advantageous.

There are certain noteworthy differences between those who are beyond sixty and those who are in middle life as regards physiology, pathology, tendencies to disease and vital resistance to it. This is particularly noticeable with regard to the two most important functions of animal life —eating and sleeping. Long ago Hippocrates declared in one of his aphorisms, "The old stand fasting much better than those of middle age, and those of middle age much better than the young. Children are very easily hurt by lack of food." This is the key-note of eating among the old. They need less food than in earlier years, and if they insist on eating as much as formerly they suffer for it. It is easy to understand the reason for this. They are not nearly as active as in middle life, and the heat processes within their body are much slower. Moderation in eating is of the first importance for the old.

(*b*) *Smoking.*—Smoking is not essential and should be avoided by young persons. The *hooka* or hubble-bubble is a better way of smoking tobacco, as the smoke in passing through the water in the *hooka* loses some of the nicotine and other injurious substances. Tobacco smoking has a soothing effect and gives to the smoker a peculiar feeling of pleasure Excessive smoking or smoking for the first time, produces giddiness, sickness, a feeling of depression and muscular weakness

Apart from nicotine, the injurious effects of cigarette smoking are due to local irritation from the aldehydes formed during the combustion from ammonia produced from other nitrogenous substances during the course of smoking, as well as from small quantities of creosote and pyridin. Smoking sometimes affects the heart and inveterate smokers may be the victims of occasional fainting fits. The worst habit is tobacco chewing, for, even if the saliva be not swallowed, a great portion of the juice is absorbed. Nicotine often causes premature hardening of the arteries, leading to arterio-sclerosis and rise of blood-pressure. The habit of smoking should never be indulged in by any one below the age of twenty-one years. In any case the smoke should not be inhaled.

Cancer of the lip and tongue, chronic sore-throat, disorder of digestion, impaired vision (toxic amblyopia), and nervous tremor are often ascribed to it. We would counsel those who have acquired the habit and will not relinquish it, to smoke the mildest tobacco—as seldom as possible—only after eating, and never in the morning, or not till after lunch; or, what is still better, not till after the evening repast.

(c) *Sleep.*—This is the only form of complete periodical rest of both body and mind. Alternate periods of rest and activity are common to all living beings. The necessity for sleep arises from the demand of certain nerve centres which undergo waste during the hours of activity.

Sleep is really rest of the brain, but the spinal cord and the sympathetic system never sleep. Like other forms of rest it varies in degree and may be very slight—mere drowsiness, or very profound—complete cessation of all the volitional functions.

A mosquito net should always be used during night. The net should be roomy and lofty, and whenever possible a fan may be fitted inside the net during summer months. Many people feel stuffy inside a net and avoid using it.

The amount of sleep varies with age, occupation and habit. Eight hours sleep at one stretch should be taken by most people in the tropics. In the plains during the height of summer when the nights are sultry, it is difficult to obtain proper rest even under a fan. Late hours should be avoided.

The amount of sleep required varies with:

(i) *Age.*—Infants sleep the greater part of the day, and the duration decreases as age advances; adults requiring about six hours' sleep. The most important factor for the retention of health in age is sleep. Those above sixty need more sleep than they did in middle life, or at least need to spend more of their time in a reclining position. It is not absolutely necessary that they should sleep all the time, but they ought to spend at least eight hours lying down with all portions of the body on about the same level, so as to

save their hearts the necessity for pumping blood against the force of gravity. The saving of work for the heart by lying down is extremely favourable for old hearts. Besides, the old should lie down for some time about the middle of their working day.

(ii) Sickness.—Weak, debilitated and sick persons require more sleep and repose than healthy ones.

(iii) Occupation.—Persons engaged in brain work require more rest and sleep than those doing physical labour.

To sleep immediately after meals is a bad practice. The bed should be firm and elastic, and exposed to the sun daily. The head should always rest on a pillow, and the body, except the head and face, should be covered with a sheet. The pernicious habit of a number of persons sleeping together in the same room and of covering the head and face is partly responsible for the feeble and weak health of the people of this country.

Mid-day Sleep.—"In India and other hot climates the tendency to indolence or lethargy is promoted by the heat, whether dry or moist, and more particularly by a hot, muggy, humid atmosphere, as in Calcutta, Dacca, or Bombay. To yield too much to this feeling, which only requires encouragement to degenerate into a confirmed habit, is injurious." is the opinion of Sir Joseph Fayrer. But it seems that a short nap, especially in the summer, particularly with those engaged in active work in the morning, is not only refreshing but invigorating.

(d) Fasting.—Fasting means complete abstinence from all kinds of food except water at specified hours. It is better to precede the fast with a preliminary purge by a dose of calomel or grey powder at night followed by some salt in the morning. A moderate fast should not extend over twenty-four hours. This causes no inconvenience except a desire for food at the usual meal times, which, however, soon disappears. The effect of fasting for longer periods is to cause the body to live on its own reserve and to use up the stored superfluous fat and the partially assimilated material, at the same time eliminate the effete materials accumulated in the body. During the fast violent exercise should be avoided, but ordinary daily avocations may be continued without any discomfort.

Fasting is a harmless and inexpensive method of keeping good health, and in certain metabolic diseases, *e.g.*, diabetes and gout, it is a valuable therapeutic agent.

(e) The Care of the Bowels. One should cultivate the habit of evacuating the bowels every day at the same time, and failure to do this results in chronic constipation. The most convenient hour is the morning before starting the day's work.

Constipation really is an evil of modern civilisation.

Sedentary habits and want of proper exercise lead to weakening of both the intestinal and abdominal muscles resulting in stasis of the intestinal contents. Modern food contains less indigestible material to form the necessary "ballast" which mechanically stimulates peristalsis. Persons suffering from chronic constipation always retain a certain amount of excremental material within their system which undergoing decomposition generates offensive gas. Congestion of the liver and production of toxæmia occur producing a deleterious effect on the general health. Headache, lassitude, lowered capacity for mental work have been ascribed to it. In old age it often causes more serious trouble.

Regulation of the diet and proper exercise will very often effect an improvement. The food should contain sufficient green leafy vegetables, fruits and salads. White flour should be avoided and replaced by whole-meal atta.

Constitution.—Individual differences in constitution exist in different persons. Some are strong and robust, while others are feeble and weak. Moreover, resistance to disease varies with the constitution. A man with a strong robust constitution should be able to resist the attacks of disease. A weak constitution denotes a condition of the body which renders it liable to attacks of disease and when thus attacked is less able to offer a successful resistance.

The constitution of a person is partly acquired and partly inherited, and a strong constitution may be enfeebled under unhygienic conditions, while a delicate one may improve under hygienic ones.

Idiosyncrasy.—By this is meant a peculiar susceptibility of some persons to be influenced by certain morbid agencies or medicinal preparations, *e.g.*, the appearance of nettle-rash with some as a result of taking shell-fish. Food idiosyncrasy is hereditary. Idiosyncrasy to disease is also seen. Thus the same cause produces different effects in different people. All persons exposed to cold do not suffer from the same trouble; some get sore-throat, others suffer from cold in the head, a few from bronchitis, while some escape altogether.

Cleanliness

The most important condition of healthful growth and development is cleanliness. Cleanliness with regard to the food we eat, the air we breathe, and the water we drink, is essential for good health. In India cleansing of the skin is of immense value inasmuch as the amount of perspiration and excretion of solids is considerable. In fact, much of the work of the kidneys and lungs is performed by the skin in hot countries. The sweat glands which open on the surface of the skin help to relieve the body of a portion of the effete material. The sebaceous glands secrete an oily

substance which acts as a natural pomade. If they are blocked up by dirt, not only is their action interfered with and extra work thrown on the lungs and kidneys, but they form favourable sites for the production or propagation of diseases of the skin. It is therefore of primary importance to see that the orifices of these glands are kept clean. Certain parts of the body like the armpits give out an unpleasant odour from their secretions and so require regular cleaning. Cleansing of the skin is best effected by soap and water.

Soap.—When an oil or fatty acid, *e.g.*, palmitic, stearic, or oleic, is acted upon by an alkali (sodium or potassium salt) soap is produced, with glycerin as a by-product. Potash soaps are known as *soft soaps*, and they are highly deliquescent; while soda soaps are called *hard soaps*. Excess of soda irritates the skin.

In India inunction of the body with some bland oil before bathing is a very popular custom. The oils usually used are either the expressed oil of mustard or cocoanut oil, either plain or perfumed. The utility of such a practice is evident. It not only keeps the body cool, renders the skin soft and supple, and helps the introduction of a certain amount of fat, but entangles the dirt of the body and facilitates its removal during bathing, especially when soap is used. Moreover, it facilitates shampooing or massaging of the body which may with advantage be done just before a bath. By kneading and rubbing, the circulation is quickened and the muscles exercised, giving an exhilarating and refreshing feeling.

Baths.—Baths are necessary not only for cleanliness but also for their beneficent action on the skin and internal organs. The sebaceous secretions of the skin and the sweat require removal. This is best done by washing or bathing the body in water. Portions of the body which perspire most require frequent cleansing to prevent accumulation which produces unpleasant odours. A clean skin is less likely to be diseased than a dirty one.

Baths may be classified according to the temperature of the water, as follows:—

Cold	33 to 65° F.
Cool	65 to 75° F.
Temperate	75° to 85° F.
Tepid ..	85° to 92° F.
Warm	92° to 98° F.
Hot	98° to 112° F.

Warm Bath.—It has a stimulating action on the skin and reflexly excites the heart and circulation. As a cleansing agent, a warm bath, when used with soap, is the best. It increases the danger of chills if there is subsequent exposure, but this sensibility to cold may be obviated by a rapid cold sponging and then drying the body quickly.

Cold Bath.—The first effect produced by a cold bath is one of shock followed by contraction of the superficial blood vessels, but the vessels dilate very soon, giving the person a feeling of warmth and pleasure. Cold baths should be taken as quickly as possible and the body covered immediately afterwards. People living close to the sea, a lake or a river, usually take "plunge baths" ; these are beneficial to the young and the healthy, and for those possessing the power of ready reaction.

Baths should not be taken during a fast, or just after a full meal, or during exhaustion. The best time for taking a bath is the morning ; if taken at night it should, as a rule, be a warm one.

The *skin* is a delicate organ, and when covered by clothing becomes highly sensitive to thermic influences. Hence the people of India, who are accustomed to keep their body bare, rarely suffer from the effects of cold to the same extent as Europeans. Cold baths should be avoided by newly arrived Europeans for whom a warm bath with a temperature between 92-98° F. is suitable. The temperature of the bath should first of all be such as can be borne without discomfort ; then it should be gradually reduced, and in this way only sensitive skins may be brought to bear perfectly cold water. But the temperature of the water should always depend upon what is called the power of reaction, that is readjustment of the free cutaneous circulation without giving rise to any internal congestion. Sometimes, instead of that pleasant feeling of exhilaration, vigour, and greater capacity for mental and physical work, the reaction is delayed and the vessels remain constricted, as evidenced by a sensation of fullness of the head and abdomen, faintness, and tight feeling over the chest and depression. Then the cold bath is unsuited and must be discontinued.

Certain skin troubles are common in the tropics. Of these *prickly heat* (lichen tropicus) is usually associated with excessive sweating during the hot months and disappears with, the onset of the rains. Acton (*Calcutta School of Tropical Medicine*) believes that it is due to the infection of the sweat glands with *Staphylococcus aureus* and *albus*, and occurs when the temperature rises above 95° F. and with high humidity. Parts that are covered with several layers of damp clothing are usually affected. Itch, scabies and ringworm are affections usually found in persons with unclean habits and are common in children. The danger of contracting these diseases through servants should be kept in mind.

Personal Cleanliness.—This involves attention to the skin, mouth, nails, hair, and other parts of the body. Cleanliness of the mouth is of special importance in the tropics. *Pyorrhœa alveolaris* is a common affection in hot countries

and not infrequently results from neglect of dental hygiene. Perhaps it is a form of scurvy due to deficiency of vitamin C. The mouth should be kept perfectly clean and the teeth regularly attended to. Tomes gives the following directions for the proper management of the teeth : "The teeth should be thoroughly cleaned at least twice a day with a brush of only moderate hardness. Any place where the food habitually lodges, and whence it is not promptly removed is quite sure to decay sooner or later ; and on the other hand teeth rarely decay on a fully exposed surface. It will be seen, therefore, that most scrupulous cleanliness is the best of all preservatives for the teeth, and that the more delicate they are, the greater the need of frequent and thorough brushing —a thing which can hardly be overdone." Deposits of tartar should receive attention, and the teeth require scaling or else the roots will become exposed and make the teeth loose. Children often suffer from caries due either to deficiency of vitamin D or to acid-forming bacteria formed when they take too much sweets, like barley sugar, which undergo fermentation. Quite a large number of children in India suffer from caries of teeth.

The *tongue* should be cleansed by a tongue-cleaner every morning. The *nails* require to be kept clean and cut short, otherwise dirt will lodge under them and may carry infection. The *hair* requires to be daily brushed and combed. The chief necessity for the hair is not so much daily ablution, for this may be carried to excess, but cleanliness. This is best done with soap and hot water, or yolk of egg, washing soda, or better still by the use of *soap nut* solution (water prepared by steeping soap nut for a few hours). One should always practise to shave oneself and avoid a barber's razor. In the same way the use or brushes, combs, clippers, etc., of other persons should be avoided. When travelling in out of the way places one may be compelled to have a barber. Always thoroughly wash in soap and hot water, or better still boil, all the paraphernalia before use. New shaving brushes should be soaked in 10 p.c. solution of formalin.

Washing of the hands and face specially before taking meals is an important safeguard against the introduction of infective agents by contact. The laws of Manu enjoin that all persons should wash their mouth, clean their teeth and open their bowels every morning before starting the day's work. Since about 90 p.c. of infections are carried to the body through the mouth with water, food, finger, dirt, etc., the importance of personal cleanliness and clean habits becomes at once apparent. Groins, armpits, round the waist where the *dhoti* is tied are places usually affected with ringworm during hot weather. This is due to the fact that the parts remain moist through perspiration, where the cause of these troubles, a tropical fungus, readily grows. These parts require thorough

cleansing at least twice a day followed by liberal application of some antiseptic powder.

Similarly children often suffer from itch, which becomes infected with staphylococcus. This is very contagious and requires careful attention.

Clothing

The principal objects of clothing are :—

1. To afford protection to the body against heat and cold, and external injuries.
2. To assist in the maintenance of bodily heat.
3. For decency and personal decoration or ornamentation (of lesser importance).

The materials for dress should be such as will exercise no harmful effect on the skin directly in contact with it. Children and old people are very susceptible to changes of temperature, and are more prone to suffer from congestion or inflammation of the internal organs. Particular care should therefore be taken in the matter of their dress.

The following points should be considered in the selection of materials for dress :—

1. The dress should in no way interfere with the healthy action of the skin ; for this purpose porous materials which absorb moisture readily should be preferred. The use of flannel or gauze banians next to the skin lessens the liability to attacks of chill. Certain materials absorb heat and are non-conductors, others again reflect more. By a careful selection we can so regulate our clothing as to suit all climates and seasons. In cold weather the non-conducting properties will not permit the escape of the animal heat except in a very tardy manner, and during hot weather they will be slow to conduct heat to the skin from without. The greatest amount of heat will be retained by wool and the least by linen.

It is of little consequence wheather the dress worn next to the skin is red, blue or white, as long as it will maintain the proper heat of the body. But colour makes a great deal of difference with regard to heat that acts upon the body from without. The same material will absorb different amounts of heat when dyed with different colours. Black absorbs the solar heat rays and white reflects them.

2. All tight clothes should be avoided, as they interfere with circulation, respiration, digestion and the action of muscles. Abolition of tight stays and adoption of light garments has done away with anæmia and chlorosis formerly so common among English girls. Other things being equal, a loose dress is warmer than a tight-fitting one. In loose-fitting garments there is a stratum of air between the skin and the articles of dress which has an important influence on the bodily heat. Air is a bad conductor of heat, and here it

acts in the same way as a separate garment. Garters of every description should be condemned—they compress the superficial veins and give rise to a feeling of heaviness and may lead to the development of varicose veins.

3. The warmth of the clothing should be distributed throughout the body uniformly.

4. All clothes should be light and warm, and their weight should be uniformly distributed.

5. They should not have any irritating or poisonous effect on the skin. Certain clothes are coloured with poisonous dyes and the poison generally used is arsenic. Some materials again have an irritating or stimulating effect on the skin, depending on its sensitiveness and the susceptibility of the individual. Some persons cannot wear woollen or flannel underwear ; but the body accommodates itself to a variety of circumstances, and a sensitive skin becomes very soon accustomed to the stimulation and ceases to respond to a rough garment. In India with a great drop of temperature at sundown it is always advisable to have warm wraps, and after violent exercise, a change of under-clothing.

Materials for Clothing

The materials used for clothing are derived partly from the animal and partly from the vegetable kingdom. From the former is derived wool, silk, fur, leather, etc.; and from the latter—cotton, hemp, flax, etc. Of these, wool, silk, cotton, and flax are the most important and commonly used. These can be distinguished by their physical and microscopical characters and by chemical reactions.

Wool.—It is the natural covering of many animals. Its value depends upon the presence of oil and fat, and in the form of cloth it imprisons a certain amount of air between its interstices, thus preventing heat passing through it. It, therefore, forms a valuable garment in India during winter. Its hygroscopic property is of much value in the hygiene of clothing.

During profuse perspiration, wool absorbs water and diffuses it through its meshes. This water undergoes evaporation, but the cooling effect which might have been harmful to the body is directed towards the garments and is removed from the skin. As underclothing, therefore, woollen garments have great advantages, and of all materials they are best suited for varying circumstances of life. Wool is, as a rule, heavy and often irritates the skin when worn next to it. For the old, the delicate, the scrofulous and the rheumatic, woollen underdress is especially beneficial. Woollen materials are less cleanly than cotton or linen ones, because they show less the outward signs of dirt, and shrink on washing. Woollen garments should be smooth and soft and the texture should be close.

Fur dermatitis.—A form of blotchy erythema of the neck and lower face forming into widespread eczematous condition. This is due to the use of dyes not properly oxidised. The dyes used are paraphenylene-diamine and metaphenylene-diamine.

Silk.—Silk is a kind of gelatinous secretion with which the silk-worm covers itself when about to change from the silk-worm to the moth stage. The fibres are about $\frac{1}{1000}$th inch wide, having no scales or surface markings. It is a bad conductor of heat, less absorbent than wool, but better than cotton. It is soft, smooth, and gives a soothing feeling to the skin and is therefore the best material for underwear.

Artificial Silk.—This is largely used nowadays for underclothing of both men and women, stockings and other articles of clothing. It allows the ultra-violet rays of the sunlight to penetrate to the skin.

Leather—Leather is chiefly used for boots, but being very close and firm in its texture it forms an exceedingly warm covering, as it allows no air to penetrate through it. The skins of the ox, sheep, horse, and goat are generally used. It is impervious to moisture and therefore keeps the skin not only hot but clammy. The chief objection to its use is that it gets stiff when dried after washing.

Cotton is the downy hair enclosing the seeds of the different species of the plant *gossypium*. The fibres are flat and ribbon-like, varying from $\frac{1}{1000}$th to $\frac{1}{4000}$th inch in thickness. Cotton has the advantage of being hard, durable and cheap. It absorbs odours readily, is warmer than linen, and does not shrink on washing, Its fibres are hard and it is inferior to wool as a warm clothing. It is mixed up with woollen materials to increase durability and to prevent shrinking. It is a good conductor of heat and conveys to the skin the heat from without and allows the body to be rapidly influenced by the conditions of the external atmosphere. But cotton materials, unlike woollen fibres, have a very feeble hygroscopic property.

Cellular cloth is made from cotton and the fibres are so woven as to leave cellular air interspaces in the texture. The enclosed air being a bad conductor helps to retain the heat of the body.

Linen.—This is made from the fibres of the flax plant. It is a good conductor of heat like cotton, and a bad absorbent of moisture. It has no advantage over cotton as an article of clothing, but is stronger and more durable than cotton, and as it can be woven into finer materials it takes a higher finish.

Cummerbund.—A chill in hot climates often leads to serious intestinal troubles in Europeans, and a flannel binder or a cholera belt should as a rule be worn, especially at night. It is rather difficult to keep a flannel binder in position,

and a cholera belt is best for the purpose. A bed sheet or a blanket is often tossed off, and the abdomen is chilled by the draught of the punkah or fan which is often kept going the whole night.

Socks or Stockings should always be worn with boots or shoes, although the practice with most people in India is to do without them. They should not be very tight or pointed at the extremity; when too short they cramp the toes, and when too long, as often happens with children with the object of "allowance for growth," a mass of superfluous material remains at the extremity of the boot. They should be washed or exposed to the sun daily as they smell badly from perspiration.

Boots and Shoes.—They should conform to the normal outline of the foot and should not squeeze or distort it, thus producing corns. The measurement of the foot should be taken when resting on the ground and always over a thick pair of socks. It is better to have a size bigger than is actually necessary. The sole should be flexible; a rigid sole destroys the main action of the foot in the act of walking. The leather should be soft and pliable, consistent with strength. Boots should be worn in preference to shoes to protect the ankles from the bites of mosquitoes.

Clothing for Children.—The general principles already laid down apply equally to children; but certain conditions render the dress of this period of life a matter for special consideration, *viz.*—

(*a*) Infants require to be properly protected by clothing. Their clothing should be soft, light, warm and loose. The notion that by clothing children lightly and by exposing them at an early period to cold, they become accustomed to fluctuations of temperature and are "hardened," is a delusion and is accountable for no small contribution to infant mortality.

(*b*) The dress should be loose and free from constrictions.

(*c*) Under no circumstances should the garments be tied tightly at the waist. They should be light and in number consistent with the due protection of the body.

(*d*) The body should be completely and evenly covered with clothing.

Exercise

Exercise is necessary at all periods of life particularly during childhood and early manhood. It is essential for the different organs of the body to work easily and effectively. It is also necessary to excite the demand for oxygen required for utilisation of food and to promote the repair and formation of tissues. It is extremely important for old age not to lapse into habits of inactivity; there is a strong temptation for a man well on in years to give up walking to a great extent and to ride in carriages and sit in the house a great

deal. What has been learnt about the heart in recent years shows that unless it gets a certain definite amount of exercise it does not do its work as well as it otherwise would. In order to derive the full advantage from exercise it must be systematic and regular so that every muscle of the body will share in it. For young people foot-ball, rowing, swimming and tennis are quite good. Incidentally the habit of breathing through the nose with the mouth completely shut should be practised. Physiological exercises are useful in the following ways* :—

1. To develop the weakly and to check overgrowth.
2. To restore those convalescent, whether generally as from illness, or locally as from injury.
3. To correct during youth various deformities.
4. To relieve certain conditions—as debility and obesity.
5. To relieve local conditions after certain lung diseases.
6. To preserve the healthy tone of the body of those who by necessity or habit, virtue or vice, cannot do so in their ordinary life.
7. To enable the body to counteract the baneful effects of educational efforts focussed on the mind.
8. As an educational measure for the mentally deficient.

EFFECTS OF EXERCISE ON DIFFERENT ORGANS

1. *Respiratory System.*—During exercise the action of the lungs should be thoroughly free, and there should not be any impediment to the full play of the chest from the dress or any other cause. The pulmonary circulation is quickened, the amount of oxygen inspired and of carbon dioxide expired is greatly increased. It is obvious that increased output demands increased supply of food and fresh air. Alcohol diminishes the excretion of CO_2 and should therefore be avoided during exercise.

2. *Circulatory System.*—Active exercise increases the force and frequency of the heart with acceleration of circulation, but this is followed by a period of depression.

3. *Muscular System.*—The nutrition of the muscles is improved, which contributes to their growth and energy. It seems probable that muscles lose water during exercise.

4. *Cutaneous System.*—Exercise promotes the action of the skin. It leads to engorgement of the vessels with increased perspiration which in evaporating from the surface of the skin reduces and regulates the temperature. But during active exercise there is less danger of chill, as the loss is replaced by a rapid supply. The risk, however, increases after exercise, and therefore the surface of the body which was exposed during exercise requires to be covered and protected from undue loss of heat.

* Albutt's *System of Medicine*, vol. (i).

5. *Urinary System.*—The excretion of urea is unaffected, but uric acid is increased. On account of the increased action of the skin the watery portion and the chlorides of the urine are diminished.

6. *Nervous System.*—Men engaged in brain work must recreate themselves with active exercise which leads to better performance of mental work.

7. *Alimentary System.*—The amount of fæces passed is lessened, and by removing constipation it induces a regular action of the bowels.

Effects of Excessive Exercise.—Excessive exercise causes either nervous or muscular fatigue. Mental fatigue is an important factor particularly with the young, the weak, and the invalid. For those with a sedentary habit it is best to have recourse to graduated exercise which requires some effort of the mind and will in its execution. Riding, rowing, swimming, etc., may with advantage be undertaken by them. For neurasthenic people an opposite course demanding less nervous effort is necessary.

After exercise the body should be washed or sponged, and since exercise increases elimination of water, salts, carbon, and nitrogen from the body it is essential that these should be replaced. Along with exercise, rest is equally necessary, and it is said that excessive exercise lowers the opsonic index even in perfectly healthy persons.

Amount of Exercise Necessary.—It is rather difficult to determine even in the case of an average man the amount of exercise that should be taken to maintain health. By "unit of work" is generally meant to be the quantity of work which is done in lifting one pound through a height of one foot; this quantity of work is called one "foot pound." According to Parkes an ordinary day's physical work for a healthy man is equivalent to raising 250 to 350 tons one foot high; this is a moderate amount, 400 tons being a heavy day's work. The amount of muscular exercise involved in this may be easily known by remembering that a walk of 20 miles on a level road is equivalent to about $353\frac{3}{8}$ tons lifted one foot; and that a walk of ten miles while carrying 60 lbs. is equivalent to $247\frac{1}{2}$ tons lifted one foot (Haughton).

It has been calculated that at an ordinary rate of three miles per hour, a man, walking along level ground, does work equivalent to raising his own weight, vertically, through $\frac{1}{20}$th the distance travelled; or raises $\frac{1}{20}$th of his weight through the whole distance travelled.

The fraction $\frac{1}{20.59}$, or approximately, $\frac{1}{20}$, is spoken of as the *co-efficient of traction*, and varies with the rate of walking. At three miles per hour, on a level ground, it is equivalent to $\frac{1}{20.59}$, at four miles $= \frac{1}{16.75}$, and at five miles $= \frac{1}{14.10}$.

To estimate the amount of work done by a man in walking the following formula is generally used:—

Let W = Weight of the man in pounds.
W′ = Weight he carries.
D = Distance walked in feet.
C = Co-efficient of traction.

Then $\frac{(W+W')\times D}{2240}\times C$ = foot tons (2,240 is the number of pounds in a ton).

The following rules should be observed with regard to exercise:—

1. Exercise should be taken in the open air, repeated daily about the same hour, and never taken just after or before a meal.
2. Every part of the body should share in the exercise
3. Exercise should be regular and systematic.
4. Chills should be avoided after exercise.
5. The amount of exercise should be regulated according to the age and physical development of the person.

CHAPTER XVI

CLIMATE AND METEOROLOGY

THE climate of a place or region is the sum total of all the meteorological conditions in their relation to animal and vegetable life. It is the average condition of the atmosphere, while *weather* denotes a single occurrence or event in the series of conditions which make up climate. The climate of a place is a series of average weather. The climate and temperature in the tropical and subtropical regions are governed largely by the following factors :—

1. The amount of humidity in the air.
2. The altitude.
3. Distance from the sea.
4. Prevailing wind.
5. Nature of the soil.
6. Proximity of mountains and hills.
7. Rainfall.

Besides the above, the following conditions affect the climate of a given locality :—

(*a*) Cultivation of the soil.
(*b*) Presence of marshes, tanks, etc.
(*c*) Presence or absence of forests.

There can be no doubt that climatic conditions have an important effect on health, as is evidenced by the geographical distribution and seasonal prevalence of disease. Further it is a known fact that climate is an important factor in determining the characteristics of the races of mankind. Amongst these may be mentioned variations in the pigmentation of the skin. There are other variations chiefly due to environment developed in the course of many centuries. In the north-west of India the dry climate and the constant struggle between man and nature have combined to produce a race brave and hardy with good physical development.

The tropical zone is that part of the earth's surface which extends from the equator to the north and south parallels of 23° 28′ 40″. The tropic of Cancer is the northern parallel, the tropic of Capricorn, the southern. Between these parallels lies the Zodiac or the apparent path of the sun. The sub-tropical zone is a region extending beyond the Zodiacal to 35° latitude north and south, and comes under the powerful influence of the sun on its approach to the tropics of Cancer and of Capricorn.

According to Supan both the northern and southern boundaries of the tropical zone are variable, the northern boundary corresponding in general to about 35 degrees north

latitude and the southern to less than 30 degrees south latitude. This region is further subdivided into Tropical Zone which lies between the isotherms of 68° F. for the temperature of the coldest month of the year and the Subtropical Zone which extends from the Tropical Zone to the isotherm of 68° F. for the mean temperature of the year.

Acclimatisation

Acclimatisation means the ability of the physiological mechanism to adapt itself, more or less, to unusual conditions. There are two views regarding acclimatisation. One school holds that acclimatisation is impossible and that Europeans can never be acclimatised in a tropical climate. According to them deterioration caused by climatological factors and endemic diseases will either kill them sooner or later; or render healthy life impossible for them; while Livingstone, the late Bishop Hannington and Dr. Sambon are of opinion that rapid acclimatisation is possible for Europeans. Huntingdon, who has made an extensive study of this aspect of the question holds the view that all progressive races characterised by high energy, civilisation and intellectual attainments live in climates characterised by variability and comparatively low mean temperature. He maintains that all civilised races in old times existed in such climates and that degeneration occurred slowly from gradual change of the climate to an equable or sub-tropical nature.

Those who hold that acclimatisation of the white man in the tropics is possible maintain that the deleterious effects from which they suffer are due not so much from the climatic conditions as to the other disabling factors like malaria, hookworm, irregular habits and other excesses. But it appears that although acclimatisation of white races is possible in course of time, any attempt at rapid acclimatisation has an influence injurious to health. If carefully selected individuals are allowed to colonise in well-chosen tropical areas with facilities for occasional changes to the hills, there is no reason why acclimatisation should prove an impossibility. But this must be very slow, and persons with a tendency to any chronic disease like gout or rheumatism, diabetes or albuminuria, or those suffering either from acquired or hereditary syphilis, are not so well suited for the purpose. There can be no doubt of the fact that some Europeans in the tropics can never adapt themselves properly to the altered conditions. They seem to be ailing off and on one way or another, and are unfitted for a tropical climate. This is possibly due to the continuance of the habits and mode of living of the temperate climate than to the climatic conditions alone. The habits and customs of the white races are adapted to the temperate regions and these must be adjusted to the new conditions and environmental circumstances.

Acclimatisation is effected by a slow process of change taking place either in the individual or in the race by constitutional modifications brought on in successive generations. The body adapts itself to the circumstances and conditions in which it is placed. All Europeans, however, cannot be acclimatised in a given area equally well. Besides the climatology of their original residence, their habits, customs, and other peculiarities have to be taken into account with regard to their adaptability for emigration.

Rapid acclimatisation with regard to Europeans is only possible in the temperate zone. It has been suggested that acclimatisation of Europeans in India is impossible unless they intermarry. But this is not true acclimatisation ; for, the race is altered and transformed into a mixed race, which ultimately has very little in common with the original stock.

Race itself does not always provide us with a definite proof of capability for acclimatisation, for in India the Hindu population, notwithstanding its Aryan origin, has thriven under unfavourable circumstances, thus presenting a striking contrast to the English (also an Aryan race), whose intolerance of the Indian climate is obvious.*

Climate in Relation to Health

Various meteorological conditions have an important influence on climate and health. Of these temperature, humidity, and atmospheric pressure demand special consideration.

Temperature.—The temperature of the air influences the climate and forms the basis for its classification. The chief source of heat in the atmosphere is the sun, but distinction must be made between the "sun heat" or "radiant heat" and the "air heat" or "shade temperature." Radiant heat is the heat directly radiated from the sun, which warms the human body and other solid and liquid objects on which it falls ; but it has very little power in warming the air through which it passes. Shade temperature is the result of the emanation of heat which the sun's rays have imparted to the surface of the earth. In sea-coast, regions, e.g. Madras, the temperature is influenced by the ocean, and the difference between the hot and cold seasons is less marked, and the climate is known as *equable*. In mountainous regions the altitude diminishes the mean annual range of temperature. The climate of inland places is rather variable, being extremely cold in winter and very hot in summer. In addition to these seasonal variations, fluctuations of temperature occur almost daily. This is less marked in places with a constant temperature and in sea-cost climates, and more marked in inland and temperate climates.

*"Climate and Acclimatisation" Green's *Encyclopædia of Medicine*, vol. ii.

Influence of Temperature on Health.—The most vigorous races are produced in places where the temperature is changeable and the difference between hot and cold seasons is great, while weak and languid races of men are to be seen in places having an equable temperature.

The high temperature of the tropics causes certain important changes in the European constitution. There is an increased peripheral circulation with a great activity of the functions of the skin causing profuse perspiration, which in its turn keeps the body temperature normal. This adjustment of the system to counteract the external heat is not often sufficient for a newcomer and the body temperature remains slightly higher than normal. The number of respirations is diminished, and the fact that hot and rarefied air contains comparatively less oxygen, the intake of oxygen with the inspiration and the output of CO_2 with the expiration are also lessened. On the whole the general effect is that of diminished vital activity. The heart is weakened with slowing of the pulse, digestion is impaired, appetite lessened and nutrition interfered with, as evidenced by loss of weight and diminished bodily activity. Anæmia is often ascribed to tropical heat, but it is generally believed that the so-called tropical anæmia or paleness is really due to pigment deposited on the epidermis. If there is real anæmia it is not due to climatic condition alone without any other causal factors. The effect of heat on the system may be either direct or indirect. Directly it may cause diseases like sunstroke or fever, or may interfere with or suspend some of the important and natural functions of the body. Indirectly it may produce heat syncope, changes in metabolism and congestive disorders affecting the liver and bowels. Stimulation of the nervous system followed by depression is the rule in tropical climates. In old residents of Uganda, Cook noted increased knee-jerk, tachycardia, insomnia and nervous irritability. The condition known as *tropical neurasthenia* is also known to occur. The real causes of these nervous manifestations are possibly faulty habits, over-feeding, lack of exercise, overwork, alcohol, worry, and perhaps sexual repression. Very hot and dry countries influence the nervous system most, and women and children are the greatest sufferers.

Effects of Cold on Health.—The effects of cold are opposite to those of heat. Whatever may be the temperature or thermometric readings, cold and its ill-effects are not uncommon in India. The cold season in Calcutta is very pleasant and invigorating to those enjoying sound health, but to many, at least at its beginning, it gives rise to chill and internal congestion. Of all the vicissitudes to which the climate of India is liable, none interfere with health so seriously as the rapid transitions of its temperature do.

The common ill-effects of the sudden transition of temperature are acute hepatitis, colic, acute diarrhœa or dysentery. When a person in the hot season leaves the plains for the hills, where the ascent is sudden, a rise of a few hundred feet accelerates the heart's action, checks perspiration, and causes profuse diuresis, or a sharp attack of diarrhœa.

Effects of Humidity on Health.—A certain amount of moisture is always present in the atmosphere, and climates have been classified into *moist* and *dry* according to the degree of humidity. We have already seen that the sensation of freshness or sultriness depends upon the rate of cooling of the body temperature (*see* page 64) which in its turn depends upon the rate of air movement and the percentage of relative humidity. Haldane has found that the maximum temperature which can be borne for some hours without the development of heat stroke depends upon the amount of moisture present in the air.

Excessive humidity retards evaporation from the lungs and skin inasmuch as the atmosphere, being very liberally charged with moisture, exerts little or no drying effect. The evaporation of moisture by which the cooling of the body is effected causes a certain amount of heat to become very oppressive, although not so trying as when combined with extreme cold. Moist climates are less healthy than dry ones, as moist air favours the growth and development of micro-organisms. Putrefactive changes take place more readily in moisture than in dryness. Sir Leonard Rogers has pointed out that there exists a close relationship between humidity and incidence of certain diseases. Thus hot moist air favours occurrence of such diseases like cholera, tuberculosis and leprosy, and a hot dry air of smallpox. Similarly atmospheric humidity exerts a most important influence on the incidence of malaria although it has no direct effect upon the parasite in the mosquito (*see* Malaria).

Effects of Atmospheric Pressure on Health.—Atmospheric pressure is an important factor of climate. It varies according to altitude and movement of air. Its influence on health may be considered under the two following heads: (1) the effects of diminished pressure, and (2) the effects of increased pressure.

(1) ***Effects of Diminished Pressure.***—760 mm. (30 in.) of mercury or a weight of 15 lbs. on every square inch is the pressure of air at the sea-level. At high altitudes the pressure diminishes on account of the rarefaction of the air; roughly, an ascent of 1800 ft. takes off 1 lb. of pressure. For an ascent of 300 ft. the temperature is reduced by 1°F. The weight of oxygen in a cubic foot of air is also diminished in proportion to the diminution of pressure.

The condition known as "Mountain Sickness" or "Aviator's Sickness" is believed to be due to the rarity of the atmosphere

at great heights and its consequent deficiency in oxygen. A person rising rapidly to a height above 10,000 feet is liable to suffer from mountain sickness. The chief symptoms are mental fatigue, irritability, headache, insomnia and in more severe cases vomiting and even collapse. Bleeding from the nose, ringing in the ears and palpitation are not infrequent symptoms. The number of corpuscles is said to increase, but in balloon ascents this is ascribed not to any fresh formation of blood, but to excessive secretion of lymph which leads to concentration of the blood. The body has however remarkable power of adjusting itself to low oxygen pressure when the change is made slowly, and persons can live for prolonged periods at heights between 15,000 to 20,000 feet without any ill effects. The adjustments of the body in response to high altitudes are slow and various. The respiration becomes deeper, so that the difference between the oxygen of the air and that of the arterial blood is reduced as low as is possible. But the most important adjustment is that the haemoglobin content of the blood is increased. Thus in the Tibet Mission it was common to find red blood cells over ten millions per cubic millimeters and the colour index 1·2. Somervell found with members of the Everest expedition at a height of 23,000 feet, that the alveolar oxygen tension was 39 mm. Hg., and the alveolar carbon dioxide was only 8 mm. Hg.

The reduction in the oxygen tension of the blood at high altitude produces chronic anoxæmia. In the following table the reduction of oxygen tension in high altitudes is shown.*

Altitude in ft. above sea level.	Barometric pr. in millimeters Hg.	Oxygen pr. in millimeters Hg.
Sea level	760	152
5,000	630	126
10,000	530	106
15,000	430	86
20,000	380	76

(2) *Effects of Increased Pressure.*—Increased pressure of air produces effects of an opposite nature, but the system soon accommodates itself to this altered condition. The effects are best observed in persons working in diving-bells, compressed air chambers (caissons), etc., and the symptoms produced are generally known as "caisson disease." In caissons the pressure is rarely 30 to 35 pounds, and divers go down to 20 fathoms where there is a pressure of 53 pounds. The accepted theory is that during compression the blood passing through the lungs becomes saturated with air which is carried to the tissues until the whole body is saturated;

* *Clark, Applied Pharmacology.*

during decompression the process is reversed. The blood gives up nitrogen to the alveolar air and returns to the tissues for more. Those organs in which the circulation is rapid will give up the nitrogen rapidly and those with a sluggish circulation slowly. The oxygen is retained in the blood and tissues; and nitrogen is liberated causing bubbles in tissues and gas emboli in blood-vessels. As a rule the workers do not suffer whilst they are in the caisson, but grave symptoms may take place after they have returned to the outside air. The common symptoms are paralysis, vertigo, vomiting, and pains in the muscles and joints, called by the work-men "bends" or "screws." In extreme instances the attacks resemble apoplexy; the patient rapidly becomes comatose and death occurs in a few hours.

One or more locks should be provided in which the pressure can be gradually reduced until approximately that of the atmosphere is reached. Divers should be instructed to come slowly to the surface. When the pressure exceeds three atmospheres the longest working period should not be more than one hour, and several hours should be permitted between the descents. A chamber should be provided where a man showing symptoms of the disease may be once more subjected to a pressure greater than that of the atmosphere. Haldane's method of graduated decompression or "Stage Method" is now widely adopted with most beneficial results.

SUNLIGHT

Light is caused by the periodic vibration or rotation of electrons, and is the result of waves of energy transmitted through the ether. The visible light rays of the sun are composed of seven primary colours, at one end of which are the red rays and at the other the blue and the violet. In addition to these there are invisible light rays. At one end of the visible spectrum are invisible rays known as the *infra-red* rays and at the other the *ultra-violet* rays. The ultra-violet rays are the chemical rays, so called from the chemical changes they produce when projected on a sensitive medium. They are invisible light vibrations, between 400 to 100 millimicrons in length. The infra-red rays include the dark heat rays.

The composition of the rays of the sun varies with the altitude and the purity of the atmosphere. In fact the atmosphere screens off the harmful radiations. The ultra-violet rays are easily destroyed or made ineffective by moisture, dust, smoke and organic matters present in the atmosphere.

Sunlight, as is well known, is essential to the well-being of all living beings, both animal and vegetable. But it is to the ultra-violet rays that most of the therapeutic effects of the solar radiation are attributed. The cells of the skin and the circulating blood in the capillaries of the skin absorb

these rays which affect the metabolism of the body (*see* vitamin D page 150). The value of sunlight for the preservation of health has long been recognised, yet till lately very little attention was paid to the utilisation of this valuable therapeutic agent so freely and so generally available. The practice of putting infants to bask under the sun after anointing the body with mustard oil is an old and time-honoured custom in India. But with the advent of modern civilisation this practice is being given up, at least in cities, with the result that the children are ill-developed, rickety and grow with a poor physique.

In the absence of sunlight the skin does not form vitamin D from the ergosterol, calcium metabolism is interfered with and the bones become soft producing *rickets*. A similar condition known as *osteomalacia* also occurs in women who have borne children and are subjected to rigorous purdah system. Rickets however is cured not only by the use of vitamin D but also from exposure to sunlight or ultra-violet rays. Apart from these diseases, tuberculosis is much common among those who live in closed rooms, and it is quite possible that lack of both sunlight and fresh air is responsible for this trouble.

Owing to the climatic and other conditions which prevail it is not always possible to make the full use of the sunlight for therapeutic purposes, therefore, the treatment by ultra-violet rays is done chiefly by artificial light, and electric incandescent and arc lights are largely used for the purpose. In India so much sunlight is available that it becomes almost unnecessary to use ultra-violet rays which is not only expensive but the same results can be obtained by other therapeutic measures. Electric lights possess properties similar to those of sunlight. The arc light is full of luminous rays, but there is also a good proportion of the ultra-violet rays. In the incandescent lamp the heat rays predominate, the ultra-violet rays are absent, being removed by the glass globe. The mercury vapour lamp which is known as the "Kromayer lamp" is largely used for the purpose. This consists of a tube from which air has been exhausted and which is filled with mercury and mercury vapour.

The ultra-violet rays only penetrate a short distance, the hæmoglobin of the blood acting as a red filter screen. Under compression from surface quartz applicators or other means, the depth of penetration is increased. It is important to note that these actinic rays will not pass through glass, paper, or thin cloth, but will pass through sterile water. Similarly a pigmented skin may prevent, or interfere with, the ultra-violet rays from penetrating.

According to Rollier sunlight judiciously applied will not only cure tuberculous affections and prevent relapses but will prevent fresh outbreaks.

The application of oil over the skin protects it from irradiation, both by reflecting the rays and by absorbing the ultra-violet rays. The horny layer of the skin by virtue of the grease reflects much of the visible rays. But the ultra-violet rays acting on the living cells of the epidermis cause *sunburns.* According to Rollier the most resistant skin of the untrained European is sunburnt by a 45 minutes' exposure to the high sun in the Alps. An exposure only of the head of a rabbit to the heat rays of the summer sunlight quickly heats up the brain without affecting the body temperature. Therefore to prevent local overheating, it is essential to use head covering and spinal covering for Europeans in the tropics. The tropical sun has a powerful heating effect on the body so that in addition to the trying atmospheric conditions the direct heating effect of the sun's rays adds greatly to the discomfort and the risk of heat stroke.

CLASSIFICATION OF CLIMATES

For purposes of classification three great climatic conditions were originally described :—

1. The hot or warm climate with a mean annual temperature of 80°F.
2. The temperate climate with 60°F., and
3. The cold climate with 40°F,

A more scientific division is made by using iso-thermal lines, as very often the regions occupying the same latitude give different annual temperatures.

For practical purposes climates are divided into: (1) cold, (2) temperate, (3) warm, (4) mountain, and (5) marine and oceanic.

(1) *Cold Climates.*—These belong to regions lying between the Poles and 50° of latitude. Here the winter is severe and prolonged, and the summer is very short. The mean annual temperature varies from 50°F. to 40°F. or may be even below the freezing-point. Rain is comparatively absent, but there is abundance of snow. Although severe cold has a tiring effect on the lungs and kidneys yet according to some observers the death-rate in these regions is the lowest in the world. Severe cold makes the inhabitants vigorous and muscular.

(2) *Temperate Climates.*—The geographical limit is from 35° to 50° of latitude, and the mean annual temperature varies from 50° to 60° F. These are the healthiest climates upon the earth, and are inhabited by the most civilised and vigorous races of the world. Four well-defined seasons exist in these latitudes, autumn and winter being usually most rainy.

(3) *Warm Climates.*—These include regions lying between the Equator and 35° of latitude on either side of it, and contain within their limits Southern Asia (including India

and China), Polynesia, Africa with its islands, North America south of California, and South America north of Uraguay, and the West Indies. They are subdivided into *equatorial, tropical*, and *sub-tropical* climates. In the equatorial the maximum temperature is 118° F., the minimum 54° F., and the mean annual varies from 80° to 84° F. High temperature, heavy rainfall with well defined dry and wet seasons are the characteristics of these regions. The heat is modified by rainfall which is rarely less than 40 inches annually, and the difference between the diurnal and nocturnal temperatures is slight. The diseases commonly attributed to warm climates are: insolation or sun stroke, cholera, malaria, yellow fever, dengue, liver abscess, smallpox, dysentery, diarrhœa, kala-azar, etc.

(4) *Mountain Climates.*—The characteristics of mountain climates are extreme heat and cold, greater purity and rarefaction of the air, and diminished atmospheric pressure due to high altitude. Mountain climates are best suited to persons with a tendency to tuberculosis.

(5) *Marine and Oceanic Climates.*—The peculiar features of these climates are greater equability of temperature, and increased moisture and rainfall, as evidenced by the climates of small islands and places on the sea-coast. The climates of Great Britain, Ceylon, and the coasts of India may be mentioned as examples. Sea air has a high salt-content and is rich in iodine. The variations of temperature between summer and winter, and between day and night, are less marked.

Effects of Vegetation and Sheets of Water on Climate

Vegetation in moderation improves the climate by keeping the air cool and equable, and counteracts the effects of radiation from the earth. Trees exert an attractive influence on the water-charged clouds and so rainfall and relative humidity are correspondingly increased.

The deprivation or absence of vegetation, as in deserts or dry lands, leads to great variations of temperature. They are very hot during the day, and owing to the dryness of the air radiation is very rapid at night when the temperature falls considerably.

The effect of the ocean, lakes or any large sheet of water is very great in influencing the climate of a place. The specific heat of water is four times greater than that of land, with the result that it takes a longer time for heating as well as for cooling. It follows, therefore, that the temperature of the atmosphere close to large sheets of water remains uniform. Sea water freezes at a temperature of about 28° F. and fresh water at 32° F., consequently the sea remains open

when the lake freezes; hence the sea exerts a greater influence in moderating winter cold and summer heat.

METEOROLOGY

Meteorology is the science concerned with the phenomena occurring in the atmosphere; while *weather* is the general condition of the air at any stated period or time, particularly of that portion of the air lying next to the earth's surface. In all meteorological observations the results obtained by different observers at different stations are recorded by instruments which must be similar in form and exposed in the same way. It is also necessary that all mistakes peculiar to these observations must not be lost sight of. All observations must be systematically and accurately made and their results interpreted.

The meteorology of India is of special interest, presenting as it does a greater variety of meteorological conditions, actions and features than any other place of similar size in the world. This is ascribed to (1) its variety and contrasts, (2) presence of a combination of tropical and temperate conditions, and (3) its being an area of pronounced monsoon conditions. The principal climatic phenomena requiring systematic record are:—

I. The temperature of the atmosphere.
II. Atmospheric pressure.
III. Movement of wind.
IV. Humidity.
V. Presence of ozone.
VI. Sunshine or solar radiation.
VII. Atmospheric electricity.
VIII. Rainfall.
IX. Presence or absence of cloud, fog, mists, and storms.

I. Temperature

Next to rainfall temperature is the most important feature of meteorological observations. This is recorded by a thermometer which is exposed in open sheds to allow a free circulation of air, and protected from the direct rays of the sun by a thick roof or thatch. In cold weather and during the hottest part of the day the temperature of the ground surface is about 10° to 20° higher than that of the air at four feet high, and this goes on increasing up to 40° or 50°. But this difference becomes less during the rains. The mean daily temperature, or simply temperature, is that obtained by adding twenty-four hourly observations and dividing by twenty-four. The temperature of a month is the mean of those of thirty days, and the temperature of a year is the mean of those of twelve months. Temperature has an important bearing in the production of certain infectious

diseases. Thus the malaria parasite ceases to undergo development in the stomach of the mosquito when the mean temperature remains permanently below 16° C. (*see* Malaria).

The temperature of the air varies at different parts of the day. It is increased by the absorption of solar radiation during the day. The variation of temperature with a maximum and minimum, dividing the day into periods of eight and sixteen hours, is the *diurnal variation*, and the difference is the *diurnal range*. There is again what is called the *annual variation* of temperature; this is the regular increase in the temperature during one-half of the year succeeded by a decrease during the other half.

The temperature of the air of a particular place varies, and the principal causes which modify the temperature are: (1) latitude of the place, (2) its height, (3) direction of the wind, and (4) proximity of the sea. In the north-western parts of India and the northern parts of the Bombay Presidency the daily range of the thermometer is very great during the months of October and November when the difference between the maximum and minimum temperature fluctuates between 30° and 35° F., while in the United Provinces it averages between 28° and 32° F. The amount of diurnal periodic change is less at sea than on land, and least on the sea-coast of islands in the tropics. The amplitude of yearly fluctuation is less at sea than on land and is least in tropical countries.

The lines which connect places which have the same mean temperature are called *isothermal lines*: these mean temperatures may remain the same either for the year or for several months.

Thermometers—Thermometers are instruments for measuring temperature. Liquids are by far the best suited for their construction, and mercury and alcohol are the fluids generally preferred. Mercury is used, as it boils at a very high temperature, and because of its regular expansion: alcohol, on the other hand, has the advantage of not solidifying even at the lowest known temperature. Of these, mercurial thermometers are more widely used.

Six's Thermometer.—This is a combination of maximum and minimum thermometers and gives a double reading. It consists of a U-shaped glass tube with a bulb at each end, the middle portion of which contains mercury. Both the tubes above the mercury and one bulb contain alcohol, and part of the other bulb contains alcohol vapour and air. In each stem there is an iron index which may be moved by a magnet. With the rise of the temperature the alcohol expands and pushes the mercury and with it the index well up the other stem. With the fall of the temperature the alcohol contracts and the mercury falls and with it pushes up the index in the other column. In this way the highest and the

lowest temperatures are recorded by the indices in the right and left limb respectively.

Maximum and Minimum Thermometers. In meteorological observations the highest and the lowest temperatures in the twenty-four hours are often necessary, for which purpose these thermometers are used. They consist of a wooden board upon which two thermometers are fixed. The *maximum thermometer* contains mercury and the tube contains a glass rod or index which the mercury does not wet or cling to. The index is pushed on with the rise of temperature, but remains there after the mercury has contracted. The *minimum thermometer* is filled with alcohol, in which the glass index is immersed. The 'surface tension' acts like a skin and pulls the index back to the lower point reached by the alcohol. But when the alcohol expands with the rise of temperature it is not displaced, thus recording the lowest temperature.

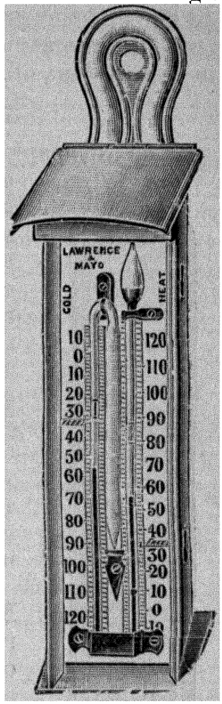

FIG. 75.
SIX'S THERMOMETER.

Vacuum or Solar Radiation Thermometer.—This is a mercurial maximum self-registering instrument having a bulb coated with lamp black to absorb the sun's rays. The bulb is placed in a vacuum glass case in order to prevent the coating from being washed off by rain. The glass case also protects the bulb from loss of heat which would otherwise take place. The instrument is placed horizontally four feet

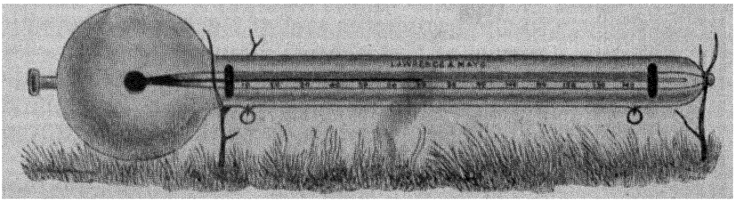

FIG. 76. VACUUM OR SOLAR RADIATION THERMOMETER.

above the ground, away from walls and trees, and exposed to the direct rays of the sun. The difference between the maximum in the sun and in the shade is the amount of *solar radiation*, or of the power of the rays of the sun.

A *terrestrial thermometer* is a minimum shade thermometer placed close to the ground with the bulb resting on the grass about four inches above the ground. If a grass plot cannot be

had the thermometer should rest on a large black board placed upon the surface of the ground, or it should be laid on snow if the ground is so covered. The difference between this minimum temperature and the air minimum in the shade is the amount of *terrestrial radiation*.

II. Atmospheric Pressure

The atmospheric pressure is determined by means of a *barometer*. It may be either a mercurial, glycerin, water, or an aneroid barometer; mercury being the heaviest known liquid is generally selected. A mercurial barometer consists of a glass tube (about 33 in. long), closed at one end, filled with mercury and inverted into a trough or cistern containing this metal. The pressure of the atmosphere at the sea-level on the surface of the mercury in the trough supports the mercury in the tube to a height of about 30 inches leaving a vacuum on top. The mercury in the tube will fall when the pressure is diminished as in mountain ascents, and will rise with an increase.

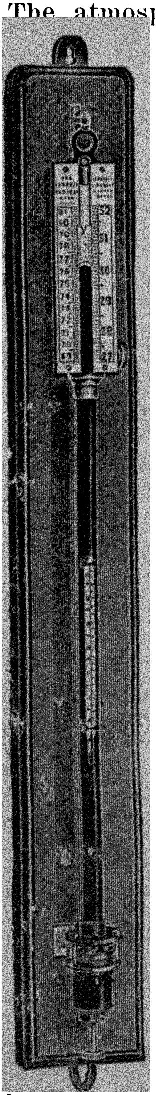

Fig. 77.

The barometer generally used is that of Fortin's. (Fig. 77). It should be fixed in a room not subject to sudden or great changes of temperature, and protected from sun, rain and wind. It must be hung vertically, in a well lighted place at a distance from any fireplace or stove, and at such a height as will enable the reading of the *vernier* comfortably when standing.

Every barometer has a thermometer attached, showing the temperature of the mercury in the barometer and of the brass tube which serves as a standard of measurement. This enables the observer to determine the proper correction to be applied to the reading of the barometer to reduce it to the standard temperature, that of the freezing point, 32°F.

Method of Reading.—First note the reading of the attached thermometer to the nearest degree; then adjust the mercury in the cistern by turning the screw at the bottom of the cistern so that the ivory point is just brought into contact with the surface of the mercury, but does not depress it. This point and its reflected image in the mercury should appear just to touch each other to form a double cone. Now adjust the vernier so that its two lower

edges should form a tangent to the convex surface of the mercury. The scale on the instrument is usually divided into inches, tenths and halftenths, and the vernier, being made equal in length to 24 divisions of the scale, is divided into 25 equal parts. Each division of the vernier is therefore shorter than each division of the scale by the 25th part of 0.05; which is 0.002 in.

First read off the division next below the lower edge of the vernier, which is, say, between 29.05 in. and 29.10 in.; the reading is 29.05 *plus* the vernier indication. Now look along the vernier until one of its lines is found to agree with a line on the scale. Suppose this is at the fourth division of the vernier; as each of the figures marked on vernier counts as a hundredth, and each intermediate division as two thousandths, the reading of the vernier will be 0.008 in. The reading of the barometer is therefore 29.05+0.008= 29.058 in.

By means of the vernier any instrument can be read to fractions of the smallest graduations into which the scale can be divided. A barometer scale cannot be clearly divided into smaller parts than millimeters or than twentieth of an inch. By means of the vernier these can be again subdivided.

The barometer having been read the following corrections must be made before the true atmospheric pressure can be determined:—

1. Correction for the temperature of the mercury.
2. Correction for the expansion of the scale attached to the barometer.
3. Correction for the latitude of the place where the barometer is placed.
4. Correction for the height above the sea-level.

The necessary correction for temperature is made by the help of tables which give the amount of allowance to be made for all ordinary temperatures and heights of the barometer. Correction for the height above the sea-level is also done by the help of tables. For each hundred feet above sea-level, one-tenth of an inch must be added to the barometric reading.

The Aneroid Barometer.—It is so-called as no fluid enters into its construction. It consists of a cylindrical metal box, partially made a vacuum, and is closed by a metal lid which being elastic is acted on by changes in the atmospheric pressure. This pressure is communicated from the box by a series of springs to an index and is recorded on a dial which has been graduated by comparison with a standard mercurial barometer. When the atmospheric pressure increases the spring is pulled down, if the pressure diminishes the spring rises. It is however liable to get out of order and therefore requires to be periodically checked against a

standard mercurial barometer. They are used when no great accuracy is required, and being portable they are used for ascertaining heights when climbing mountains, or during aeroplane ascents.

Barometric Fluctuations.—Variations in the atmospheric pressure, though rarely extending over a few inches, have a practical value as indicating the general weather conditions. Air retains moisture and on the amount of this moisture in the air depends the formation of rain. The presence of moisture in the air increases its volume, so that one cubic foot of dry air which weighs 546.8 grs. at 50°F. becomes, when saturated

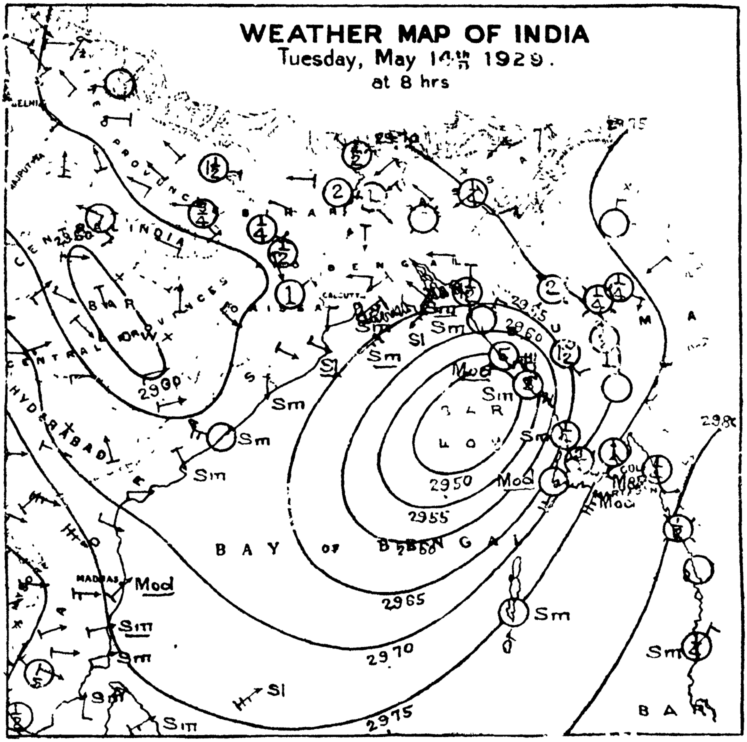

FIG. 78.—SYNOPTIC CHART SHOWING CYCLONIC SYSTEM. The arrows show the direction of the wind. The figures show the barometric pressure of the isobars.

with moisture, 1.1021 cubic ft. and weighs 550.9 grs. This fact of moist air being lighter than dry air causes a fall in the barometer which indicates imminent rain.

Other causes may also lead to barometric fluctuation, *e.g.*, movement of wind, although this movement depends to a

great extent on the presence or absence of moisture in the air. It is by the early recognition of the barometric changes that weather forecasts are made.

The changes in weather over a wide area brought on by daily, monthly and annual irregular variations of the barometric pressure are principally divided into *anticyclonic* if the weather is good, and *cyclonic* if the weather is bad. Nowadays barometric readings at a given time over an extended area, including ships at sea, are telegraphed to a central station to be recorded. If observations of stations having the same barometric pressure are recorded on a map we get a *weather or synoptic map*, and the lines connecting such places or stations are called *isobars*, which arrange themselves in certain typical forms associated with certain kinds of weather. It will be observed (*see* fig. 78) that an area of low pressure is encircled by a series of isobars of increasing pressure from centre outwards; such a system indicates "low" or "depression" and is *cyclonic*. On the other hand, the isobars may enclose an area of high pressure and each succeeding isobar increases towards the centre which has the highest barometric reading; such a system is "high" or *anticyclonic*. (*See* Fig. 79). Secondary cyclones, V-shaped depressions, wedge-shaped depressions, cols, etc., are only modifications of the primary types.

III. Movement of Wind

Wind is the effect of disturbance of equilibrium constantly proceeding in the freely mobile atmosphere. The causes of these disturbances are differences in atmospheric pressure brought about by changes in temperature and moisture, aided by physical and other factors. The air derives most of its heat from contact with the earth's surface which becomes more heated near the equator than in other parts, while the amount of moisture which it can hold increases with the temperature. In order to restore the atmospheric equilibrium the air moves from the anticyclonic system, where the barometer is high and pressure greatest, towards the centre of a cyclonic system where the barometer is low and the pressure least. Thus in October and November the temperature over the land area becomes lower than over the sea near the equator, and the pressure being higher, the air from the land blows towards the equator. Again in April and May, the plains of northern India become more heated than the sea near the equator, consequently the pressure becomes less over the land than over the sea and a current is set up in the opposite direction, *i.e.*, from the sea to the land.

The primary factor in the meteorology of India is alteration of seasons. The north-east and south-west *trade winds* are set in motion by the movement of the earth and are due

to the incessant movement of cold air from the poles, replacing the heated air of the tropics. The south-west monsoon is a season of winds of oceanic origin, of high humidity and

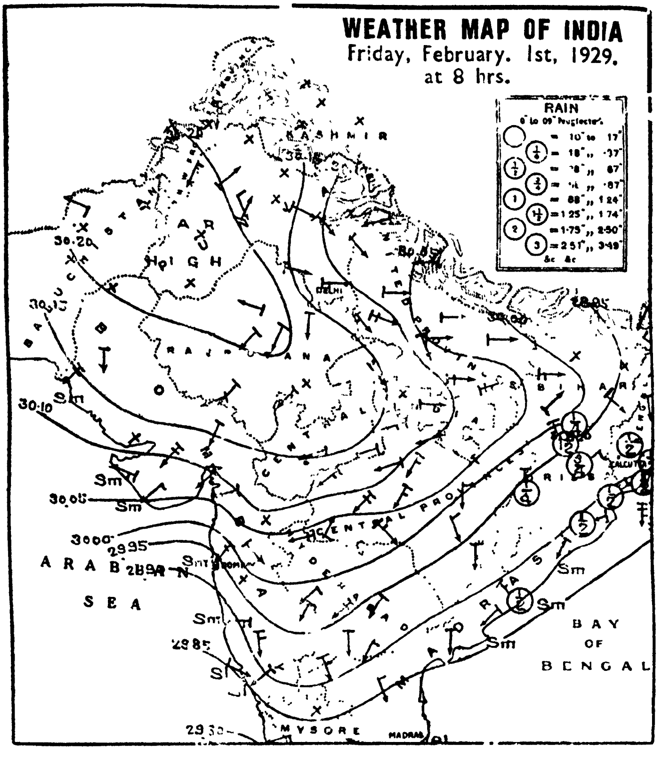

FIG. 79.—SYNOPTIC CHART SHOWING ANTICYCLONIC SYSTEM.

of frequent and heavy rains over nearly the whole of India. It arrives in the south of India about the beginning of June and is deflected by the Peninsula into two currents—one the Bay of Bengal current which proceeds over the Bay to Burma, Assam and Bengal, and is then deflected in a north-east direction by the Himalayas up the Ganges Valley through Behar, the United Provinces and the southern portion of the Punjab; the other current, the Arabian Sea current, proceeds over the coast of Bombay and Madras Presidencies causing much rain and then proceeds onwards over Central India to meet the Bay current. This monsoon lasts from July to October and then retreats by the way it came. The north-east monsoon, on the other hand, is of continental origin, and is therefore dry, except where it has travelled over some sea. Hence the north-east monsoon in India is

characterised by clear lightly clouded skies with occasional rain. These are therefore appropriately termed *wet* and *dry* monsoons, suggesting as they do the most important and prominent features of the seasons in the land areas of India. In fact about 90 per cent. of the annual rainfall of India occurs during the south-west monsoon. The dry monsoon is again divided into two periods—one of comparatively low and the other of increasing and high temperature. The wet monsoon is similarly subdivided into two periods—June to September is the *monsoon proper*, while October to December is called the *retreating monsoon*. During the cold weather period India is characterised by clear sky, fine weather, large diurnal range of temperature, and light land winds. The months of November and December are the most pleasant of the year in Northern India.

Anemometer.—The pressure and velocity of winds are recorded by instruments called anemometers, of which there are several kinds. Robinson's wind anemometer being considered the best. It consists of a metal cross provided with hollow hemispherical cups at their ends, and revolving horizontally on a vertical axis which, by an arrangement of a screw, records the movements on a dial. From the number of turns made in a given time the velocity of the wind is deduced.

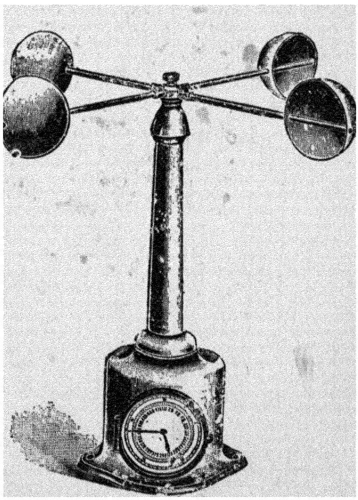

FIG. 80.—WIND ANEMOMETER.

The cups move at a rate equal to only one-third of that of the wind, and allowance is therefore made for this in graduating the instrument. The instrument should be kept clean and properly oiled, and fixed at least twenty feet from the ground.

IV. ATMOSPHERIC HUMIDITY

Water is being constantly evaporated into the air which has a definite capacity for absorbing moisture. The amount of moisture which the air can hold varies considerably not only with the temperature but with the season, and with the elevation and position. During the height of the wet monsoon, it is about 10 to 12 grs. per cubic foot in the coast districts of Bengal and Bombay. It is usual to speak of the amount of moisture present in the air as the *degree of*

humidity. The actual amount of moisture present in a given volume of air is called *absolute humidity*. This absolute humidity has an important bearing in the epidemicity of cholera in India, and Rogers has pointed out that cholera never becomes widespread when the absolute humidity is under "0.400". *Relative humidity* indicates the percentage amount of moisture in the air, regarding saturation as 100. It exerts most important influence on the incidence of malaria (*see* malaria). When the air at any given temperature contains as much water as it can hold, the air is then called *saturated*, and the warmer the air the greater is the amount of moisture that it can hold. It follows that if the temperature of a certain quantity of saturated air be raised it ceases to be saturated as it can now take up more watery vapour. On the other hand, if it be cooled it will reach a temperature at which it becomes incapable of holding that amount of water, and some of it will condense and appear as rain, hail, mist and dew. The precipitation of moisture on the surface of the earth or on grass, leaves, etc., is called *dew*, and is caused by the air coming in contact with the cold surface of the earth at night and parting with its moisture from loss of temperature. When the temperature rises again the dew disappears, and the mean of the temperatures of appearance and disappearance is the *dew point*.

The dew point is determined by means of a hygrometer, and is calculated by means of a dry and wet bulb thermometer. Having noted the readings of the two thermometers, the dew point is ascertained either by the use of Glaisher's tables or by the following formula of Apjohn :—

$$F = f' - \frac{t - t'}{87}$$

t and t' = Dry and wet bulb readings.

f' = vapour tension corresponding to wet bulb temperature.

F = vapour tension at the dew point.

For the application of this formula a table of vapour tension is necessary. Therefore having ascertained the dry and wet bulb temperature, both the dew point and relative humidity can be obtained by the use of Glaisher's table, where a series of factors, Glaisher's factors, is given for each reading of the dry bulb thermometer. The dew point is determined by the aid of Glaisher's factor from the following formula :—

$$D = t - (t - t') \times F$$

D = dew point.

F = factor as obtained from Glaisher's table.

When t(dry bulb reading) = 58°

t'(wet bulb reading) = 48°

and factor for 58° being 1.9 (from Glaisher's table)

then $D = 58 - (58 - 48) \times 1.9 = 39$

therefore dew point = 39

GLAISHER'S TABLE OF FACTORS FOR DRY BULB TEMPERATURES

D.B.T.	Factor.	D.B.T.	Factor.	D.B.T.	Factor.
45	2.16	61	1 87	77	1.70
46	2.14	62	1.86	78	1.69
47	2.12	63	1.85	79	1.69
48	2.1	64	1.83	80	1.68
49	2.08	65	1.82	81	1.68
50	2.06	66	1.81	82	1.67
51	2.04	67	1.8	83	1.67
52	2.02	68	1.79	84	1.66
53	2.0	69	1.78	85	1.65
54	1.98	70	1.77	86	1.65
55	1.96	71	1.76	87	1.64
56	1.94	72	1.75	88	1.64
57	1.92	73	1.74	89	1.63
58	1.9	74	1.73	90	1.63
59	1.89	75	1.72	91	1 62
60	1.88	76	1.71	92	1.62

Relative Humidity. It may be defined as the ratio of the mass of aqueous vapour present in the air at a given temperature to the mass of aqueous vapour necessary for the saturation of the same volume of air. It is calculated as follows :—

$$\text{R.H.} = \frac{\text{Force of vapour at dew point temp.}}{\text{Force of vapour at dry bulb temp.}} \times 100$$

The vapour force factor is obtained from Glaisher's tables and is the amount of mercury in inches that could be supported by the pressure of the vapour in a cubic foot of saturated air at that temperature.

VAPOUR TENSION REPRESENTING SATURATION

Temp. F.	Force of Vapour.	Temp. F.	Force of Vapour.	Temp. F.	Force of Vapour.
40.0	0.247	46.5	0.317	53.0	0.403
40.5	0.252	47.0	0.323	53.5	0.41
41.0	0.257	47.5	0.329	54.0	0.418
41.5	0.262	48.0	0.335	54.5	0.425
42.0	0.267	48.5	0.342	55.0	0.433
42.5	0.272	49.0	0.348	55.5	0.441
43.0	0.277	49.5	0.355	56.0	0.449
43.5	0.283	50.0	0.361	56.5	0.457
44.0	0.288	50.5	0.367	57.0	0.465
44.5	0.294	51.0	0.374	57.5	0.473
45.0	0 299	51.5	0.381	58.0	0.482
45.5	0.305	52.0	0.388	58.5	0.491
46.0	0.311	52.5	0.396	59.0	0.50

Hygrometers.—The amount of moisture present in the air is registered by the *hygrometer*, of which there are two

kinds, *viz.*. the *direct* and the *indirect* hygrometers. Daniell's, Regnault's and Dine's are examples of direct types, while the wet and dry bulb thermometer and psychrometers are classed as indirect types.

Daniell's Hygrometer.—This consists of two globes connected by a bent tube. One globe, made of black glass, is partly filled with ether and a thermometer dips into it. The other bulb as well as the remaining portion of the tube contains ether vapour. The empty bulb is covered with muslin which is kept moist with ether. The ether in evaporating cools the bulb and the loss of temperature so brought about condenses the ether vapour inside the bulb and tube, which in its turn causes an evaporation of the ether inside the thermometer-containing-bulb, which cools down and reduces the temperature of the air around it until it becomes so low that it forces the air to part with some of its moisture which condenses upon the surface of the bulb. As soon as this happens the temperature from the attached thermometer is taken and the cooling process is stopped. The surrounding air warms the ether bulb and the dew disappears, when the thermometer is read again. The mean of the two readings is the dew point. The closer together the readings the greater the accuracy.

Dine's Hygrometer.—The theory is exactly the same as with Daniell's. A stream of cold water from the vessel A is run through the channel D which is covered by a thin blackened glass. The temperature is recorded by a thermometer the bulb of which is placed just under it. The water

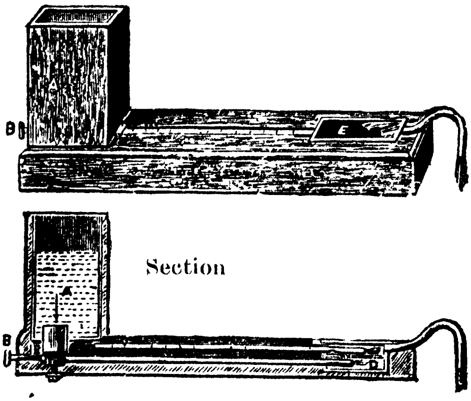

FIG. 81.—DINE'S HYGROMETER.

cools the glass plate and when the first trace of deposit of dew is formed the flow is stopped and the reading of the thermometer is noted. Wait till the dew disappears and read the thermometer again. The mean of the two temperatures is the dew-point.

Psychrometer.—This is an instrument of greater precision and is as trustworthy as the dew-point apparatus. It is used nowadays in preference to the *wet and dry bulb hygrometer.* It consists of two thermometers, one covered with thin muslin. Both the bulbs must be of the same size, style and sensitiveness. Two types of psychrometers are generally used, *viz.* the *Assmann's Ventilating Psychrometer*, and the *Sling Psychrometer* (see Fig. 82). The sling pattern is provided with a handle, which permits the thermometer to be whirled rapidly. During the time of observation the muslin covering should be thoroughly saturated with distilled water and the thermometers whirled rapidly for 15 to 20 seconds, stopped and the wet-bulb reading noted. This is repeated several times till the two successive wet-bulb readings are almost the same, showing that it has reached its lowest temperature. The dry-bulb readings give the true temperature of the air, and the difference between the dry and the wet bulb enables one, by means of tables, to obtain the percentage of humidity, the dew point and the vapour pressure of the air.

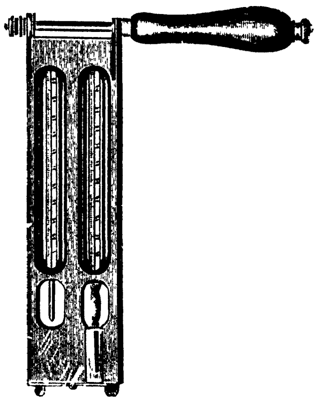

FIG. 82.—SLING PSYCHROMETER. (Courtesy of Cassela & Co., Ltd.)

V. ATMOSPHERIC OZONE

It is popularly believed that the presence of ozone in the air is conducive to health, but this requires further confirmation. Potassium iodide and starch papers are used for the detection of the presence of ozone in the air, but they are not reliable, as other substances, especially nitrous acid, turn them blue.

VI. SUNSHINE

The duration of sunshine influences the climate to a great extent and is recorded by means of Campbell-Stoke sunshine recorder. It consists of a sphere of crown glass four inches in diameter and three pounds in weight and supported on a pedestal in a metal zodiacal frame. It should be fixed in such a position that the sun can shine on the instrument the whole of the time it is above the horizon. The image is received on a prepared card inserted at the proper focal distance. When the sun shines it burns away or chars the surface at the point on which its image falls and so gives a

record of the duration of sunshine The sunshine should be measured in hours and tenths of an hour, not in minutes.

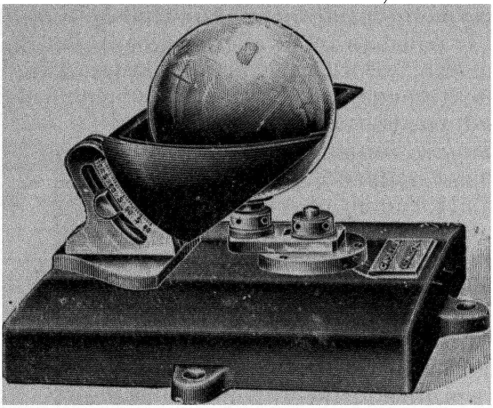

FIG. 83.—SUNSHINE RECORDER
(Courtesy of Cassela & Co., Ltd.)

VII. ATMOSPHERIC ELECTRICITY

The atmosphere is always charged with electricity, and many hypotheses have been put forward to explain its presence. It has been ascribed to (1) growth of vegetation, (2) evaporation of water containing salts in solution, (3) friction of the air against the ground, and (4) combustion The fact that powerful atmospheric phenomena are accompanied by rain and hail seems to suggest a connection between the excitation of electricity and condensation of aqueous vapour. When the sky is cloudy the electricity is sometimes positive and sometimes negative. It is nearly always positive in fine weather. The electricity of the ground is always negative but differs with the humidity and temperature of the air.

VIII. RAINFALL

The distribution of rain is an important factor in regulating the climate of a place, and a fair conception of the general character of the climate can be made from the amount of rainfall and its distance from the equator. Certain local conditions cause important variations; they are the soil, elevation, exposure to winds and position, whether on the sea-coast or inland.

The amount of rain which falls in different countries varies with the local circumstances, and other things being equal, most rain falls in tropical countries where evaporation is abundant; in fact rainfall diminishes from the equator to the poles. Under similar conditions the quantity of rain decreases with the distance from the sea and increases with the height above sea-level. The average rainfall during the

south-west monsoon in the coast districts of the Konkan is about 100 inches and increases up to about 300 inches on the summit of the hills at an elevation of 3000 to 4000 feet. Sylhet at the foot of the Assam hills has an average total of 157 inches, while, Cheeraponjee on the Assam hills at an elevation of about 4000 feet has an average of 458 inches. The following is a statement of mean or normal rainfall in India derived from the average of about 2000 stations distributed over the whole country :—*

Cold weather (January to February)	0.99	Inches
Hot weather (March to May)	4.58	,,
S. W. monsoon (June to September)	34.65	,,
Retreating S. W. monsoon (Oct. to Dec.)	4.95	,,

It appears that of the mean annual rainfall, 12 per cent. occurs during the dry and 88 per cent. during the wet season; but the ratio differs in different parts of India, varying for the dry season from 3 per cent. in Bombay to 19 per cent. in Bengal, 21 per cent. in the Punjab and 30 per cent. in Assam.

The rainfall during the cold weather is due chiefly to disturbance in condensation in an upper current: it is very irregular in its occurrence. The cold weather rainfall, small though it may be, is of great economic value, especially over a large part of northern and central India, as upon it the winter crops of non-irrigated districts depend.

The hot weather rainfall presents much greater contrasts. This rainfall is often accompanied by dust storms and is small in amount averaging only about 1 inch accompanied by thunder-storms of great violence and intensity, especially in Assam, Bengal, Arrakan, Lower and Upper Burmah It is of great value for the tea crops in Assam where it averages 31 inches and in Bengal it favours the early spring crops of rice.

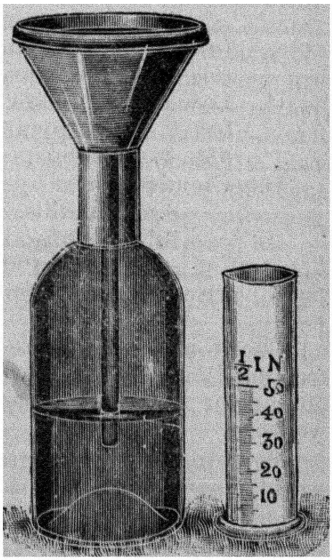

FIG. 84. RAIN GAUGE.

Rainfall is measured by a *rain-gauge* which consists of a copper funnel leading to a receiver. The funnel has a sharp rim and is usually 5 inches in diameter. The rain having been collected into the receiver is measured in a glass vessel graduated to correspond with $\frac{1}{100}$th of an inch of rainfall. The

* Imperial Gazeteer of India.

reading is generally taken at 9 A.M. daily, and the instrument is placed on the ground in an open place with the rim about 1 foot above the earth. In time of snow, melt the collected snow by adding a known quantity of warm-water to it, and the extra water derived from snow is counted as rain water. Roughly, one foot of snow may be taken to represent an inch of rain.

IX. Clouds

A *cloud* may be defined as a mass of vapour condensed into minute water particles which float in the air, differing from mists and fogs in occupying the higher regions of the atmosphere. one to four miles above the surface of the earth. A mist is a cloud near the ground, and a fog is a cloud resting on the earth and occurs on the surface of the ground and is warmer than the air in contact with it. A cloud is therefore a fog at a greater height. A *cloud line* is the level below which the formation of clouds rarely takes place. Clouds have been classified by Hildebransson and Abercromby as follows :—

A. Highest clouds, mean height 9000 meters.
 (*a*) 1. Cirrus.
 (*b*) 2. Cirro-stratus.

B. Clouds of mean altitude, 3000 to 7000 meters.
 3. Cirro-cumulus.
 (*a*) 4. Alto-cumulus.
 (*b*) 5. Alto-stratus.

C. Low clouds, below 2000 meters.
 (*a*) 6. Strato-cumulus.
 (*b*) 7. Nimbus.

D. Clouds formed by diurnal ascending currents.
 8. Cumulus. Top, 1800 meters; base, 1400 meters.
 9. Cumulo-nimbus. Top, 3000 to 8000 meters; base, 1400 meters.

E. Elevated fog, below 100 meters.
 10. Stratus.

Those marked (*a*) are detached or rounded forms, most frequently seen in dry weather; those marked (*b*) are wide-spread or veil-like forms, most frequently seen in wet weather.

CHAPTER XVII

INFECTION AND CARRIERS OF INFECTION

By *infection* is understood the introduction into the body, without contact with the patient, of some pathogenic micro-organisms which are capable of multiplying within it at the expense of the host. Diseases depending on such an infection are known as "infective" diseases, and are transmissible in most instances by inoculation. If the micro-organisms are from time to time discharged from the body of the host, either with the excreta, secretions, or in some other way, the disease becomes "infectious" or "contagious," according to the ease with which another person becomes infected. and the material which carries the infection is termed the "contagion". Thus in smallpox the contagion is conveyed from person to person through the air, and this is therefore an infectious disease. Ringworm and syphilis require close contact for infection to take place ; and are therefore contagious diseases. In other instances, *e.g.*, malaria, infection is conveyed by an intermediary, *viz.*, mosquito ; and insects which act as intermediaries are known as *vectors*. Although it is customary to draw a line of demarcation between infection and contagion, broadly speaking they are much the same, and according to the modern sense of the term the so-called contagious diseases are infectious. All diseases depending on the entrance of a living organism may coveniently be classed as infectious. *Fomites* are substances capable of absorbing, retaining or transferring infection. They refer to inanimate objects like bedding, clothing, etc.

Infection may be *general* or *local*. In tetanus and diphtheria, the organisms after infection cause some local disturbance and other general symptoms, and cannot be detected in the circulation. In enteric fever, the germs are present in the general circulation. In both instances, however, the constitutional changes are due to the toxins and not to the germs themselves.

Some persons are peculiarly susceptible to certain diseases, others offer some resistance to infection. This susceptibility is called *predisposition*, which may be natural, artificial, or acquired, and the resistance, as opposed to predisposition, is known as *immunity*. The liability to infection also varies in man according to age, sex, climate, season, locality and surroundings. But the susceptibility of the tissues varies greatly, and infection or invasion of the body by bacteria does not occur every time the body is exposed.

Certain terms are used to express the relative prevalence

of infective diseases ; they are : (*a*) *Epidemic*—when a number of cases break out by infection from a common source at one time and the outbreak is then followed by a period of rest. *Epizootic* is a term analogous to epidemic, but refers to diseases of the lower animals. (*b*) *Endemic*—when a disease is constantly present in a certain district and is peculiar to that district or locality. Endemic diseases sometimes flare up and become epidemic. (*c*) *Sporadic*—when a disease occurs only in isolated cases. (*d*) *Pandemic*—when the epidemic is spread over a large area or over the whole world.

Incubation.—After an infection with an organism producing disease, a variable period elapses when the germs have not sufficiently developed in the human host and consequently no characteristic symptoms of the disease are manifested. During this period the ordinary health is apparently maintained. This latent period is the "*incubation period.*" The duration of this period varies, each case differing from every other, and depends partly on the amount of poison entering the system at the time of infection, and also on the resistance offered by the individual. During this period the patient may remain perfectly healthy or may feel a little malaise. During this incubation period a person exposed to an infection requires to be isolated or placed in quarantine. This is of great value in considering measures for the suppression of infectious diseases.

The following table gives an approximate statement of the period of incubation and the duration of the communicability of some of the most important microbic diseases :—

Disease.	Incubation period.	Infective period.
Chickenpox ..	10 to 12 days	3 weeks
Cholera ...	a few hours to 5 days	2 ..
Dengue	3 to 6 days	2 ..
Diphtheria	1 to 8 ,,	6 ,,
Enteric Fever ...	5 to 20 ..	6 ..
Influenza	1 to 4 ..	2 ..
Measles	8 to 15 ..	4 ..
Mumps	12 to 22 ..	3 ,,
Plague ...	3 to 10 ..	3 ..
Smallpox	12 ,,	6 ,,
Whooping Cough ...	4 to 14 ..	8 ..

Sources of Infection.—All infectious diseases arise from invasion of a susceptible host by organisms derived from a pre-existing invaded host This host is known as the source of infection. It may be man or some lower animal. Although water, air, food, soil, etc., may also cause infection they are really vehicles by which the infection is carried, and not actual sources of infection. The fact that most infections

are carried direct from man to man, makes the work of sanitarians a task of considerable difficulty. Thus it is more easy to prevent an animal borne disease than one carried by man. Preventive medicine is therefore intimately related to sociological problems. Apart from human beings, infections are due to agents not derived from man but from infected animals. Thus plague is derived from rats, anthrax from cattle, Malta fever from goats, etc.

Bacteria.—Bacteria or *Schizomycetes* are minute vegetable organisms which are the active causes of infective diseases. They are devoid of chlorophyll and multiply by simple transverse division or fission and are thus distinguished from the yeasts where multiplication takes place by budding or gemmation. The size of bacteria varies, but they are all microscopic, measuring from 0.3μ to 30 to 40μ in diameter or length. Some bacteria are motionless while others are more or less motile. The shape is also very different; some are spherical, others ovoid, or rod-shaped, etc., and they have been classified into five main groups according to their shape as follows:—

(*i*) Coccus,—round shaped.
(*ii*) Bacilli,—rod shaped.
(*iii*) Spirilla,—spiral shaped.
(*iv*) Streptothrix,—long and filamentous.
(*v*) Vibrios,—elongated and curved.

According to whether bacteria thrive upon living or dead matter as well as according to their most characteristic effect they have been classified for the sake of convenience into *zymogenic* (fermentative), *aerogenic* (gas producing), *saprogenic* (putrefactive), *toxicogenic* (poison producing), and *pathogenic* (disease producing) organisms. According to whether the organisms grow in the presence or absence of oxygen they are classed as *aerobes* and *anaerobes*. Some are *facultative*, *i.e.*, are capable of multiplying under either one or another condition. Some bacteria are harmless both to animals and plants, and apparently under no circumstances give rise to disease in either. These are known as *saprophytes*. Others again live on the bodies of plants or animals and produce disease; these are known as *parasitic* or *pathogenic* bacteria.

Each bacterium has the property when introduced into the body of manufacturing toxins peculiar to itself, and the distinguishing symptoms of a disease are due more to the toxins than to the presence of the bacillus itself. How the toxin is produced is a debatable point. Some hold that it is formed from the cell-plasma of the bacillus, others regard it as the product of the action of the bacillus on the protein substances. The functions of the body may therefore be disturbed by the bacteria in two ways: (1) through the absorption of their excreted toxins or by the changes wrought on the proteins by these toxins (simple intoxication,

as in diphtheria), (2) by their growth and the production of toxins within the body of the bacteria (infection, as in typhoid fever).

Channels of Infection.—The micro-organisms of communicable diseases enter the body mainly through (*a*) *the skin* (inoculation), (*b*) *the respiratory tract* (inhalation), and (*c*) *the digestive tract* (ingestion). The different organisms take different channels for entrance into the body, and if introduced by a route other than the one to which adapted, they fail to gain a foothold. The channels of infection are distinct from modes of infection. In cholera the usual channel is the digestive tract, but the mode of infection is from infected excreta, either by direct contact, or through milk or some other vehicle.

1. *The Skin* (*Inoculation*).—Generally the contagia of glanders, anthrax, vaccinia, tetanus and rabies are thus received. Abrasion facilitates infection from syphilis, gonorrhœa, etc. Malaria, plague, yellow fever, sleeping sickness, filariasis, etc., are all conveyed by biting insects and inoculate the system with the specific organisms through their bites on the skin.

2. *The Respiratory Tract* (*Inhalation*).—The chief source of infection by inhalation is through air pollution. The dissemination takes place by so-called droplet infection at short range from the mouth and nose. It is doubtful whether infection can be carried to long distances by the air or wind. The only diseases which may be called airborne are perhaps smallpox and measles. Outside air contains relatively few bacteria, where they are considerably diluted, and most of the organisms pathogenic to man die when exposed to sunlight. But the air of ill-ventilated houses and crowded places is often surcharged with different pathogenic bacteria. For instance, tram-cars, ill-ventilated school rooms, offices, etc., in crowded places often contain micro-organisms of diphtheria, whooping cough, measles, influenza, cold, tuberculosis, etc., in sufficient concentration to infect others exposed to these surroundings. During sneezing, coughing, speaking and other expiratory efforts the fluid contents of the mouth are sprayed into the air in minute particles. These droplets contain the germs of any infection that may be in the mouth. This mode of infection is known as "droplet infection."

3. *The Digestive Tract* (*Ingestion*).—Quite a large number of infections are conveyed from person to person indirectly through the medium of water, food, insects, etc. Of these water or food when contaminated often carries infection and causes epidemic outbreaks. Enteric fever, cholera, and dysentery are, as a rule, produced through infection of milk, water, or other food. Malta fever is carried through goat's milk and guinea worm disease (Dracontiasis) follows swallowing of infected *cyclops*.

Modes of Transmission.—These may be (1) direct, (2) indirect, (3) by carriers, and (4) intermediate or through insects.

1. *Direct Infection.*—This is by far the most common mode of transference of the virus of a given disease from one person to another, and is known as "contact infection." Contact infection plays an important role in the spread of diseases whose virus leaves the body with the different excreta. The discharges from the mouth and nose would cause diseases like tuberculosis, measles, influenza, common cold, whooping cough, etc., by means of *droplet infection.* Hands and fingers contaminated with the different excreta also play an important part in contact infection, for instance, in the spread of cholera, dysentery, typhoid, etc. Syphilis and gonorrhœa are other examples of *direct contact infection.* Similarly the act of kissing, or the use of contaminated towels, handkerchiefs, pencils, cups, spoons, etc., may cause infection by direct contact.

2. *Indirect Infection.*—Quite a large number of infections are conveyed indirectly through some vehicle, the chief vehicles being water and food. Soil and fomites also play some part in indirect infection.

3. *Carriers.*—A carrier is a person who harbours a pathogenic organism without showing any sign of the disease. Thus a person may be a typhoid carrier without giving evidence of any symptoms of this disease. Similarly a person may be a diphtheria or dysentery carrier. Carriers may be acute, chronic or temporary. Acute carriers harbour the micro-organisms for a few weeks after convalescence; chronic carriers continue to harbour the organisms for months and years; and temporary carriers harbour and discharge pathogenic organisms for a short time only but without suffering from the disease. The detection of carriers is of great value, since it enables one to take proper preventive measures. A typhoid carrier should not be allowed to handle food or be employed in the kitchen.

4. INSECTS

Sir Patrick Manson was the first to draw attention to the important part played by insects in the transmission of disease. Malaria, yellow fever, relapsing fever, dengue, sandfly fever, plague, filariasis, sleeping sickness and probably kala-azar are all transmitted by the agency of this group of the animal kingdom.

Insects are intimately related to man; except perhaps the domestic animals no single group of animal life enters more into the daily existence of man than insects. "They live on us and around us; in our food, our clothes, our furniture, our houses; we eat them or their products, we collect them and sew them on our clothing." There are insects which are useful, but there are many which affect man in other ways.

The role played by ticks, biting flies and other blood-sucking arthropods in the transmission of various diseases

to mammalia is one of great economic importance. The malaria-carrying mosquito, a constant scourge of tropical and semi-tropical countries, has been shown to be a factor in the life history of great nations. The plague flea has taken its toll of millions from the human race. Africa, the greatest of all the Continents, lies under the ban of biting flies, such as the tse-tses, which transmit trypanosomiasis. Over half a million human beings have died during the first ten years of the present century from fly-borne sleeping sickness. Thus it will be seen that these invertebrate parasites affect profoundly the economic status of the present and succeeding generations.

The ways or means by which insects may carry the germs of disease from one host to another are to be carefully considered. They may act as *passive agents*, *i.e.*, may simply convey the infection on their contaminated bodies or in their excreta. This form of transmission is purely mechanical, and it is immaterial by what group or species of insect it is effected. But the chief interest at the present time centres on the part the blood-sucking insects play in the propagation of different parasitic diseases. Such insects afford a ready means of introducing a blood parasite from one animal to another. But in some instances it is still debated whether the parasite is carried from one animal to another in a purely mechanical way, undergoing no change *en route*, or whether, as in the case of the *Plasmodia* of malaria in anopheline mosquitoes, the parasite undergoes a series of changes before it is able again to infect the blood of a healthy animal.

The blood-sucking species of insects belong to the following Orders:—DIPTERA, which includes the mosquitoes, sandflies and tse-tse flies; SIPHONAPTERA, or fleas; ANOPLEURA, or lice; and HEMIPTERA, which includes the bed-bug. The face mite, itch insects, and the tick are not strictly speaking insects, for they belong to another class of the Arthropoda known as ARACHNIDA; but since they act in certain cases as agents in the transmission of disease they will be considered here along with the true insects.

General Characters of Insects.—The bodies of insects are covered with a tough skin or exoskeleton, and are divided into three distinct parts; the head, provided with two antennæ or "feelers", and eyes and mouth parts of variable form; the thorax, composed of three segments, and carrying three pairs of legs, and one or two pairs of wings; and an abdomen composed of nine to eleven segments some of which may be difficult to recognise. The endoskeleton is formed by the turning inwards of parts of the exoskeleton, forming plates for the attachment of muscles, and the nervous system is represented by a double cord, swelling at intervals, which runs throughout the length of the head and body. Insects are not provided with lungs, but breathe by means of

particular organs termed *tracheæ*, the main trunks of which extend parallel with one another along each side of the body, and communicate with the external air by lateral openings called *spiracles*. The digestive system is represented by the alimentary canal, which commences at the mouth, and runs centrally through the body to the extremity of the abdomen. The sexes of all insects are distinct, and they are reproduced from eggs.

The following is a list of the common diseases carried by insects:—

1. *Mosquitoes.*—Malaria, filariasis, yellow fever, dengue.
2. *Fleas.*—Plague.
3. *Lice.*—Typhus fever, Indian relapsing fever, trench fever.
4. *House flies.*—Typhoid fever, cholera, dysentery.
5. *Tsetse flies.*—Sleeping sickness.
6. *Sandflies.*—Sandfly fever, and possibly oriental sore and kala-azar.
7. *Ticks.*—African relapsing fever, Rocky Mountain spotted fever, tick typhus.

MOSQUITOES OR GNATS

The mosquito belongs to the Order DIPTERA, Family Culicidæ, Sub-family *Culicinæ*. Like all the members of this Order it deposits *eggs*, from each of which is produced a *larva*, which afterwards becomes converted into *pupa* or *nymph*, from which the adult insect emerges. The egg, larval and pupal stages are spent in water, and therefore the presence of water is essential for the existence of all mosquitoes.

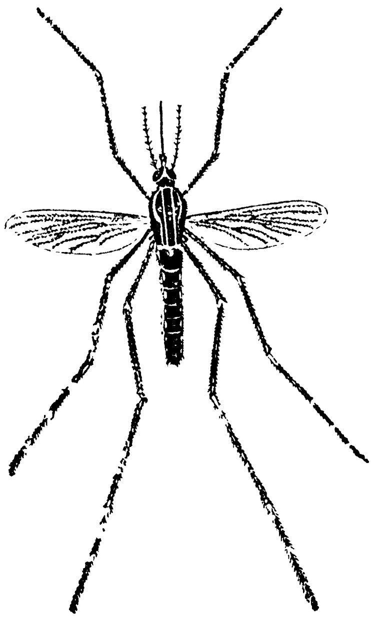

FIG. 85.—AEDES ÆGYPTI (STEGOMYIA FASCIATA OR CALOPUS).

The species of mosquitoes which are of importance to a medical man are those belonging to the genera *Anopheles*, *Culex* and *Aedes* (*Stegomyia*). Various species of *Anopheles* transmit the malaria parasite from man to man. *Culex fatigans* is the most important carrier of *Filaria* (*Wuchereria*) *bancrofti*.

Aedes ægypti (better known as *Stegomyia fasciata* or *calopus*) is the vector of dengue and of yellow fever.

Aedes ægypti is a purely domestic mosquito, rarely found far away from towns or villages, and like other bright coloured mosquitoes it bites chiefly during the day, and only occasionally at night. Each female deposits from twenty to seventy-five eggs at a time, and these float on the surface of the water separately, instead of being cemented together to form rafts, as is the case with *Culex*. The eggs are very minute, black, cigar-shaped and extremely resistant: they are generally found in cisterns, rain-water barrels, disused tins, earthenware pots and other small artificial collections of water. *Aedes ægypti* is recognised by the broad, flat, imbricated scales which completely cover the head and abdomen, and which are also present on the scutellum, the scales giving a characteristic satiny appearance. It is a beautiful insect, strikingly marked with black and white, and the most characteristic feature, by which it may be differentiated from every other mosquito is the presence of a lyre-shaped white mark on the dorsum of the thorax.

Anopheles and **Culex.**—The *eggs* are deposited either on the surface of the water, on some moist object floating on the surface, or on damp mud near water.

In the case of *Culex* hundreds of eggs are cemented together in the form of rafts, each consisting of from 200 to 500 eggs, and easily distinguishable with the naked eye. The eggs are about the size of caraway seeds, and are of a brownish black colour. The *Anopheles* female produces from 100 to 250 eggs in each batch. They are shaped like little boats, and are kept afloat by means of air cells. The eggs are deposited singly, without any cement substance, and float separately or touching one another in the water, frequently forming star-shaped or parallel patterns. They are difficult to detect with the naked eye, and look like minute specks of dust. The typical egg is about 0.7 to 1.0 mm. in length, white in colour when first laid, but subsequently changing to black.

FIG. 86.—CULEX AND ANOPHELES Larvæ in breathing position at the surface of water.

The *larvæ* emerge from the eggs in from one to three days, depending on the temperature, and are large enough from the first to be seen with the naked eye. The larva swims

actively about in the water, and has a flattened head with a pair of large eyes, a globular thorax, and an abdomen consisting morphologically of ten segments, of which however only nine can be separately distinguished. The respiratory tubes, which serve to carry oxygen to the tissues have their external openings on the combined eighth and ninth segment. The head, thorax and abdomen are provided with numerous hairs, the character and position of some of these being of importance in the identification of species.

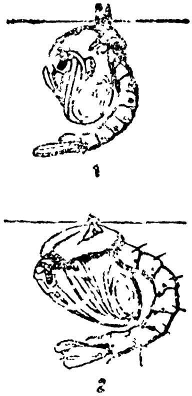

FIG. 87.—PUPÆ OF MOSQUITOES.—1, CULEX; 2, ANOPHELES.

In *Anopheles* the respiratory tubes open directly on the dorsal surface of the abdomen, whilst in *Culex* and *Aedes* these are prolonged into a projection known as the *siphon tube*. The absence of a siphon tube is therefore peculiar to the larvæ of *Anopheles*. In *Aedes* these tubes are short and thick, while in *Culex* they are usually thin and long. The abdomen of *Anopheles* larvæ is provided with certain fan-shaped structures known as *palmate hairs*, which are attached by a short stalk to the outer dorsal surface of the segments. Owing to the presence of these structures and to the absence of siphon tubes they float parallel with the surface of the water. *Culex* and *Aedes*, owing to the presence of siphon tubes and the absence of palmate hairs float below the surface of the water, while the head and body hang downwards. The larvæ are very voracious, and feed on small aquatic plants and animals, whilst some species are cannibalistic. They cast their skins four times before entering the pupal stage. The larvæ of many species of *Aedes* have a smaller head and less prominent thorax than *Culex*, and assume an almost vertical attitude in the water. Certain small species of fish have a natural tendency to prey on mosquito larvæ, which protect themselves by taking shelter amongst the aquatic weeds.

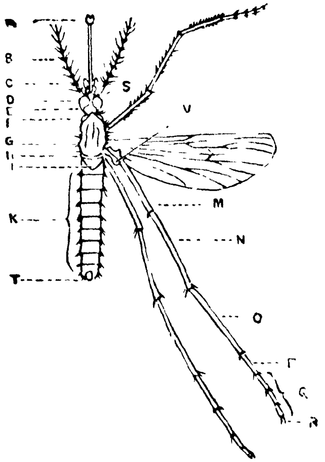

FIG. 88.—MOSQUITO.

Proboscis; B, Antennæ; C, Palpi; D, Eyes; E, Vertex; F, Occiput; G, Mesothorax; H, Scutellum; I, Metathorax; K, Abdomen; M, Femur; N, Tibia; O, First tarsal; P and Q, Tarsal segments; R, Ungues; S, Fronts; T, Egg depositor; V, Haltere.

The Pupa.—The larva completes its development in about 8 to 10 days, when a new creature known as the *pupa* or *nymph* is formed from it. This is shaped like a comma and is lighter than water, on the surface of which it floats and moves about actively. It has a globular body, which includes the head and thorax, and a small tail. It has no mouth, and therefore cannot feed; it breathes by means of two small tubes, one on either side of the thorax. In about 24 to 48 hours the pupa case splits and the adult insect or *imago* emerges. Just previous to this the pupa becomes straightened out and lies flat on the surface of the water, the empty case subsequently acting as a raft on which the mosquito rests until its wings have dried.

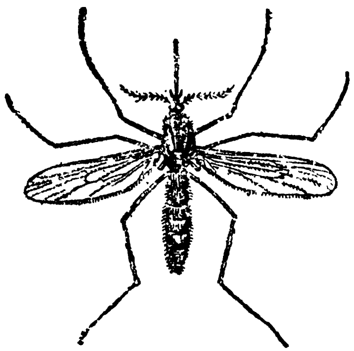

FIG. 89.—CULEX (female).

The Imago.—The adult mosquito has a rounded head with prominent eyes. The head is attached to the thorax by a narrow neck, and carries the sensory and suctorial organs. On either side and in front of the eyes are the antennæ or "feelers." These are long segmented structures provided with hairs. The suctorial and piercing organ is the proboscis, which consists of the *labrum-epipharynx* or upper lip, two *mandibles*, two *maxillæ*, the *hypopharynx* (through which runs the salivary duct) and the *labium* or lower lip. The labium forms a groove, which ensheathes all the other mouth parts, except the palpi. The thorax carries a pair of wings and three pairs of jointed legs which are attached to the under surface. The anterior portion of the thorax is known as

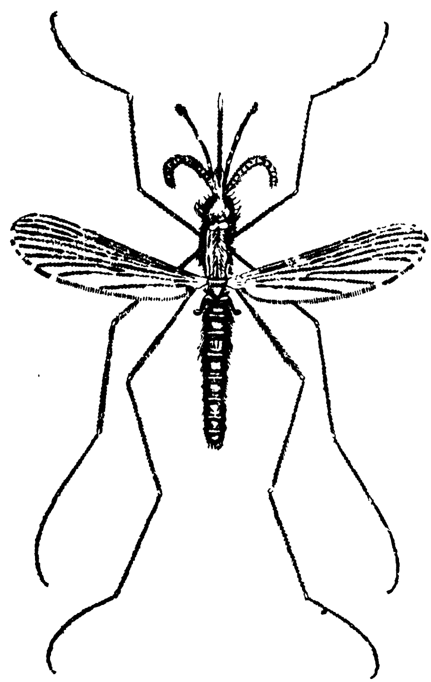

FIG. 90.—ANOPHELES FLUVIATILIS (LISTONII) (female).

the *prothorax,* the middle portion the *meso-thorax,* and the posterior portion the *meta-thorax.* By far the greater part of the thorax is made up by the meso-thorax, the other two segments being greatly reduced. A prominent ridge, known as the *scutellum,* lies transversely across the upper surface of the thorax posteriorly. This is bar-shaped in *Anopheles,* but trilobed in *Culex.* The abdomen consists

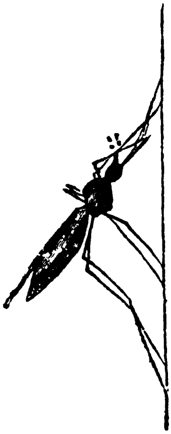

Fig. 91.—Resting position of Anopheles.

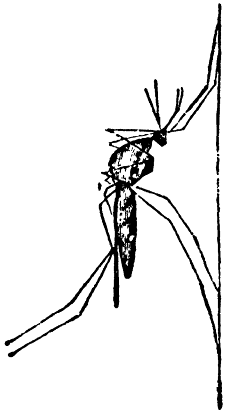

Fig. 92.—Resting position of Culex.

morphologically of eleven segments, but only seven or eight are easily distinguishable. The ninth and following segments in both the male and female are considerably modified to form the external genital organs. The anal opening is situated at the tip of the abdomen.

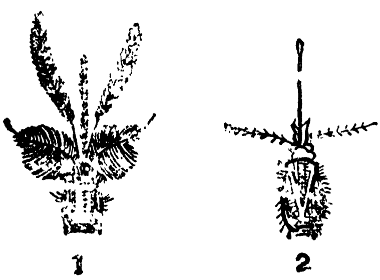

Fig. 93. Head & thorax of Culex. 1, Male; 2, Female.

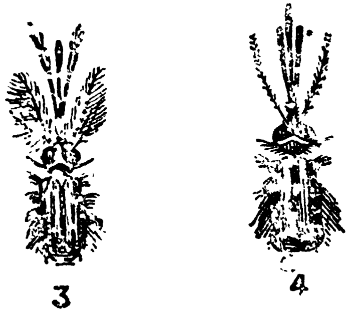

Fig. 94.—Head & thorax of Anopheles. 3, Male; 4, Female.

Anopheles mosquitoes when resting assume an attitude with the body at an angle with the surface on which they are sitting, and with the proboscis in line with the body. *Culex* mosquitoes, on the other hand, assume a hump-backed attitude, with the body more or less parallel with the surface on which they are resting, and with the proboscis not in line with the body. Other points of difference between *Anopheles* and *Culex* will be found in the table at the end of this section.

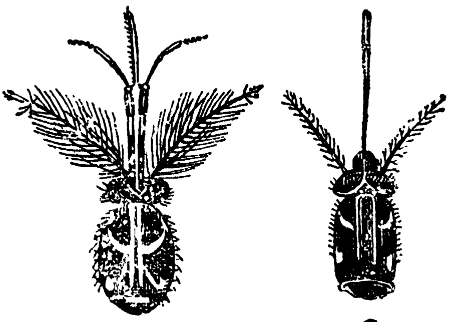
5 6

FIG. 95.—HEAD AND THORAX OF AEDES 5. Male; 6, Female.

Habits of Mosquitoes.—Different species of mosquitoes vary widely in their habits. Some forest species feed almost exclusively on wild animals, and rarely enter houses. Others feed principally upon the blood of cattle and other domestic animals, rarely biting man, whilst others again (and among them the most dangerous malaria carriers) show a marked preference for human blood. It must not be concluded that because an engorged mosquito has been caught in a cattle-shed it has necessarily fed on the animals stabled therein; on the contrary, it is frequently found that such mosquitoes contain human blood. This is especially the case in the tropics, where it is a common practice to cook food in the houses. The mosquitoes are driven out by the smoke, and take refuge in the nearest convenient shelter, which is frequently a cattle-shed. A study of the blood-feeding habits of the various species of *Anopheles* is of great importance, for the amount of malaria present in any locality is largely determined by the degree of contact between man and the mosquito.

Male adult mosquitoes feed exclusively on vegetable juices, and take no part in the spread of disease, but the females are blood-suckers, and this is why their proboscis is modified for piercing the skin. It takes about a minute or so for the mosquito to fill her stomach, and with every bite she injects a quantity of salivary fluid, which sets up local irritation and inflammation. This is said to keep the blood fluid, thus rendering it more easy of digestion. A blood meal is necessary before the female can produce a batch of eggs.

A single female will deposit several batches of eggs in one season, each consisting of some hundreds; and the newly hatched insects will themselves produce eggs within a week or so of their emergence from the pupa case. Generally the

female selects water for oviposition in which there is a good supply of food for the larvæ.

During the day-time mosquitoes as a rule select shady places in which to rest and avoid the sun. They hide themselves under the leaves of trees and bushes, in tree-holes, in dark corners or cupboards in houses, in cowsheds and stables, frequently among the thatch. and in other places where there is shelter from sunlight, wind and cold. They are most active just after sunset and just before sunrise, but some species bite in the day-time, especially when the weather is cloudy or in the deep shade of forests. Mosquitoes are especially voracious when the relative humidity of the atmosphere is high.

In countries where the winters are cold all the male mosquitoes die off, but the females hibernate in sheltered places. Some species hibernate in the larval or in the egg stage. In certain parts of the tropics the adult females pass the hottest months of the year in a very sluggish state, hidden away in tree-holes, thatch, etc. This is known as æstivation. Mosquitoes in this condition will not deposit eggs, even if artificial breeding-places are provided for them.

Range of Flight.—This subject is of great practical importance, for in planning anti-larval measures it is most necessary to know the size of the area over which control must be practised. Where the food-supply is abundant anophelines will rarely fly farther than is necessary for them to obtain a blood meal ; but there are various factors which influence the range of flight. The distance of spread from breeding places varies directly with the intensity of breeding, and inversely with the density of habitations in the vicinity. The direction of the prevailing wind, the presence or absence of a belt of forest, and the species of *Anopheles* concerned have also a marked effect, the larger species usually flying greater distances than the smaller. As a general rule it may be stated that the average normal range of flight rarely exceeds one-half to three-quarters of a mile, but where breeding is profuse, habitations scarce and the direction of the wind favourable, anophelines may penetrate to distances of $1\frac{1}{2}$ to 2 miles from their breeding places, or even farther.

Breeding Places of Mosquitoes.—Whilst all mosquitoes deposit their eggs on water, the different species show a wide variation in their choice of breeding place. *Culex* mosquitoes frequently breed in cesspools, gully traps, drains, masonry tanks, earthenware vessels and other collections of water in and around houses, stables, etc.

Aedes ægypti is notorious for selecting any kind of artificial receptacles containing water for depositing its eggs.

Anopheles on the other hand usually prefer clean fresh water, and this is particularly the case with most of the most dangerous malaria carriers. The larvæ of some species

are found chiefly in still waters, such as swamps and ponds; others prefer running streams, pools in connection with streams, or irrigation channels. Some comparatively rare species breed in water collected in tree-holes; others again, as for instance *A. sundaicus*, the notorious malaria vector of the Andamans and Burmah coast, breed in salt or brackish water. *A. stephensi* is well-known as being the principal urban malaria carrier in India, and breeds freely in wells, cisterns, fountains and garden tanks, though its larvæ are also found in rural areas in the beds of streams and elsewhere. It is the only malaria carrier in India which is able to adapt itself to the conditions of life obtaining in cities. *A. subpictus* ("*rossii*") will breed practically in any collection of water, even when heavily contaminated with sewage.

The various species differ also in their preference for sunlight or shade as regards their breeding places, a matter of vital importance when measures of control are under consideration. Thus *A. umbrosus* breeds in water protected by deep shade, whilst *A. maculatus*, *A. minimus* and *A. sundaicus* prefer bright sunlight. Hence the indiscriminate cutting down of jungle may in certain localities merely provide excellent breeding places for dangerous malaria carriers.

The following species of Anophelines are the principal carriers of malaria in India :—*A. culicifacies*, *A. stephensi*, *A. fluviatilis*, *A. minimus*, *A. sundaicus*, *A. maculatus*.

Some observers in Bengal are of the opinion that *A. philippinensis* and *A. annularis* play an important part in the transmission of malaria in certain areas of that province.

The following species are considered to be the principal malaria carriers in countries other than India :—

ASIA

China,—*minimus*, *maculatus*, *hyrcanus*.
Dutch East Indies,—*sundaicus*, *aconitus*, *maculatus*, *hyrcanus*, *kochi*.
Malay States,—*maculatus*. *sundaicus*, *umbrosus*, *aconitus*.
Philippine Islands,—*minimus*.
Mesopotamia,—*superpictus*, *stephensi*.

AMERICA

North,—*quadrimaculatus*, *punctipennis*, *crucians*.
Central,—*tarsimaculatus*, *albimanus*.
South,—*albitarsis*, *argyritarsis*, *pseudopunctipennis*.

AFRICA

North,—*bifurcatus*, *sergentii*, *elutus*, *algeriensis*, *superpictus*, *multicolor*, *rhodesiensis*.
Central, East and West,—*gambiæ* ("*costalis*"), *funestus*.

EUROPE,—*maculipennis*, *superpictus*.

AUSTRALASIA,—*punctulatus*, *annulipes*.

The distinguishing characters between *Anopheles* and *Culex* are given in the following table :—

Stage of Life	*Anopheles*	*Culex*
Egg, or ovum	Boat-shaped Laid singly, and often form patterns on surface of water. Usually found in fresh clean water.	Cigar-shaped. Found cemented together in rafts. Usually found in still water, often collections of dirty water in and near houses.
Larva	Has no siphon tube. Lies horizontally with surface of water. Has palmate hairs (except *A. umbrosus*)	Has conspicuous siphon tube. Lies at an angle with surface of water. Has no palmate hairs.
Pupa, or nymph	Not easily distinguishable	
Adult, or imago.	Body at an angle with surface on which it rests. Proboscis in straight line with body. Scutellum bar-shaped. Abdomen often not scaled; scales if present not closely imbricated. Palpi of female as long as proboscis Palpi of male clubbed. Wings usually spotted.	Body more or less parallel with surface on which it rests. Proboscis not in straight line with body. Scutellum tri-lobed. Abdomen always clothed with dense layers of closely imbricated scales. Palpi of female always shorter than proboscis. Palpi of male not clubbed (except *Theobaldia*.) Wings usually unspotted.

SANDFLIES

These insects are the carriers of sandfly fever, a disease which is characterised by fever of short duration, usually lasting from three to five days. The fever was described by Colonel Birt from Malta and Crete as phlebotomus fever. It occurs in India in an endemic form in Chitral and sporadically elsewhere. It is probable that *Phlebotomus argentipes* is the insect vector of kala-azar in Bengal. It is possible that

oriental sore may be transmitted through the agency of sandflies.

There are two distinct species of insects popularly known as sandflies: (1) The *Simulium*, belonging to the family *Simuliidæ*, commonly known as Black-flies or Buffalo-gnats, and (2) the *Phlebotomus*, or true Sandflies or Owl-midges.

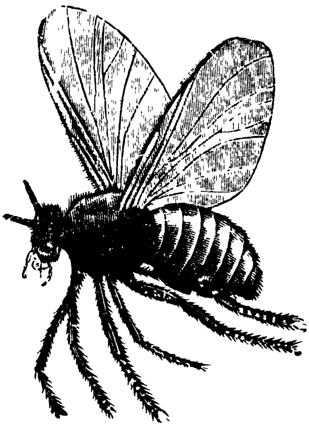

FIG. 96.—THE SIMULIUM

The Simuliidæ.—These are small, thick-set, dark-coloured flies, though in hot climate they are sometimes light-coloured. They have a hump-backed appearance and are provided with short, thick, cylindrical antennæ of eleven segments each. They have a peculiar dancing flight, and the females are blood-suckers. The larvæ live in running waters, they are vermiform with swollen posterior ends, and are provided with two fan-shaped cephalic plumes which vibrate in water in the act of conveying food to the mouth. They adhere by their hind-part to aquatic herbs and stones, and spin threads which by anchoring them to suitable projections protect them from being carried away. When full-grown a cocoon is formed into which it pupates. They are common in all temperate climates, but in tropical countries are more plentiful in high altitude. The females are voracious blood-suckers and usually bite the larger animals. They fly long distances to obtain a meal of blood. *Simulium damnosum* is the carrier of *Onchocerca volvulus* in West Africa. *S. reptans* is found in Europe. *S. indicum* is the "pipsa" fly of India.

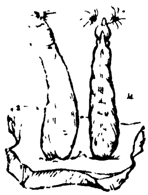

FIG. 97. LARVÆ OF SIMULIUM

The Phlebotomus.—This includes *Phlebotomus papatasii*, *P. chinensis*, *P. sergenti*, *P. minutus* and *P. argentipes*. Whittingham and Rook (*British Medical Journal*, Dec., 15th, 1923) of the Sandfly Commission, have shown that the virus of the sandfly fever is handed on from generation to generation. In fact the fever was transmitted to man by the bites of phlebotomi bred in sterile soil in England. The following description is based on the work of Whittingham and Rook.

Phlebotomus papatasii is a small midge 3 mm. in length, delicate build, and thickly covered with fine, long hairs. The body is of a pale lemon tint. The eyes are relatively

large, black, and conspicuous. The antennæ are long, filiform and consist of sixteen segments. The proboscis is long and contains delicate piercing organs ; on either side the bushy labial palps are folded back on themselves to protect the proboscis. The wings are hairy and lanceolate. They are held erect in a characteristic attitude resembling deer's ears, except when newly hatched or shortly before death.

The female is recognised by the spindle-shaped abdomen, while in the males the presence of the external genitals gives the posterior extremity of the abdomen the appearance of the tail of an aeroplane.

The Ovum—It is 0.385 mm. long, 0.12 mm. broad, ovoid in outline, being convex dorsally and flattened or slightly concave ventrally. Its surface is moist, glistening and when fresh of a pale yellow colour. It soon becomes opaque, and daily for eight days, changes colour, passing from light to dark brown, and then to sepia. During this period the surface markings on the egg appear. The egg matures in nine to ten days in summer, and under favourable atmospheric conditions the larva emerges within five minutes of the first appearance of the head through the egg-shell. Excessive moisture retards this process and may even cause death. Drying is more injurious than moisture.

The Larva.—This consists of a head and twelve segments. The head is furnished with strong jaws. Throughout the

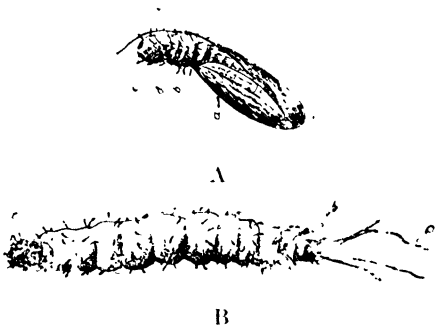

Fig. 98.—A, Fertilised Ovum showing ruptured egg-shell and the Larva emerging. B, The Larva of Sandfly. (Whittingham and Rook)

Fig. 99. Emergence of Imago from Pupa case (Whittingham and Rook)

whole larval stage a white Y-shaped mark and a pair of small antennæ are seen on the back of the head (c, Fig. 98. B.). Both the head and the body are filled with short, white or yellow hairs.

For the first five days of life the larva feeds voraciously and rapidly grows in size. The larva goes through a series of moulting, and pupation occurs at the end of the fourth month

The pupa.—The length of time between the hatching of the ovum and pupation may be 24 days, and if the insect hibernates, it may be as long as 202 days.

The larva gradually empties its gut for two and three days before pupation. An excess of moisture, or a temperature below 65° F. retards this process. During this time it seeks a drier spot. The surface of the body looks bloated, dull, wax-like and semi-transparent; and the insect becomes very sluggish. After several slow arching movements the chitinous head covering separates on the dorsum from the rest of the skin and the pupa emerges.

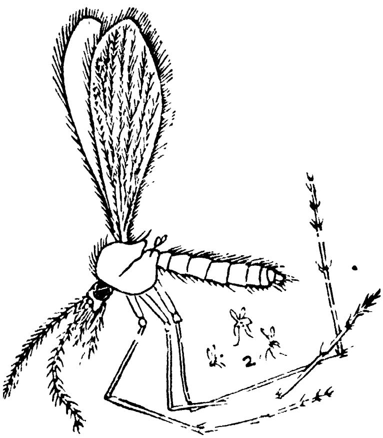

FIG. 100.—FEMALE PHLEBOTOMUS. (2.) SAME NATURAL SIZE (After Alcock).

The newly emerged pupa is 3 mm. in length, club-shaped, moist, glistening and of a milkwhite colour. The head of the club is formed by the head and the thorax both of which are fused into one mass. By the ninth day of pupal life the component parts of the imago are seen, and pigmentation of the eyes and hairs become marked.

The Imago.—The newly hatched imago is snowy white except for the black piercing eyes. The body and wings are covered with long downy hairs. The wings are moist and crumpled up, and held in a horizontal position. When the wings are dry they are raised at an angle of 45° above the body, and the insect is able to fly and feed.

When disturbed they jump to one side, almost like a flea, a characteristic movement of the sandfly.

Like mosquitoes, the males are harmless, but the females are blood-suckers, and being of a smaller size they have the advantage over moquitoes in getting through ordinary mosquito netting. They avoid light and bite chiefly at night, and in shady places during the day. They ordinarily bite the wrists and the ankles even through the socks and light clothing. The actual bite is not felt; the pricking sensation is caused by the injection of saliva which takes place a few seconds later. The saliva delays the clotting of the blood which is sucked up and appears in the stomach within ten seconds.

They are generally to be found in or near bathrooms, near the floor, under bricks and stones, and in damp, shady places. They breed in the droppings of chickens, and in

places where vegetable organic matter like food refuse is undergoing decomposition, particularly in the drains adjoining cookhouses.

Protection against sandfly is very difficult, and was almost impossible during the last war. Large numbers are killed by fumigation with sulphur or spraying with formalin or cresol. Essential oils, chiefly oil of cassia, are effective as long as the smell lasts. Fine-mesh (22 holes to the linear inch) mosquito net affords a real measure of protection. Good walls and floors, occasional painting and varnishing of all doors and windows are worth trying.

CHIRONOMIDÆ OR MIDGES

These little blood-thirsty insects belong chiefly to the genus *Ceratopogon*; they are found in most parts of the world, and are very annoying to man. Midges are distinguished from the mosquitoes by their small head, short proboscis, and by the absence of scales on the body and wings, and by a different venation. In their resting attitude they raise the fore-legs and hold them up in front of the head, while the mosquitoes raise the hind ones above the thorax and abdomen. They are extremely small flies, males being somewhat larger than females. They are blackish or greyish-brown in colour, with wings often hairy and frequently speckled with greyish-brown blotches. When at rest with the wings closed one over the other, they look like blades of a pair of scissors.

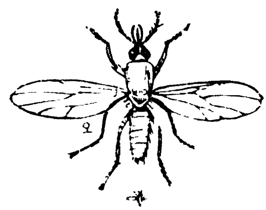

FIG. 101.—MIDGE. (Ceratopogon).

With the exception of one variety, which is terrestrial, all the other species lay eggs in water which pass through the same stages as those of the mosquito. The larvæ of the terrestrial variety feed on rotten vegetable matter. How far these are responsible as carriers of disease is not settled.

Patton has described a new Indian blood-sucking midge common in Madras, which he has named *Culicoides kiefferi*.

FLIES

Flies belong to the family *Muscidæ*, and the common house-fly and blue bottle are familiar to all. They belong to the order *Diptera* and are the most widely distributed of all insects. The house-fly is a quarter of an inch in length, mouse grey in colour, with four narrow black stripes on the thorax. The proboscis ends in a pair of fleshy lobes and when not in use is folded away into a cavity under the head. This proboscis is merely adapted for sucking food and is not capable of piercing the skin.

The female deposits her eggs only in materials that will provide food and a home for the maggots. The food materials must be such as can be easily swallowed, moist and warm. It cannot breed in perfectly dry materials. Normally it breeds in decaying refuse of all sorts, and is especially partial to horse manure. It also breeds freely on human excreta, which makes it very dangerous to human beings, carrying as it does the germs of intestinal diseases. A female house-fly will lay as many as 120 to 500 eggs at a time. Taking the egg batch to be 120 eggs in each case the progeny of a single house-fly will number 432,000 in seven weeks, *i.e.*, in three generations, taking the time of development from egg to fly as seven days (Austen). Each house-fly passes through the four following stages:—

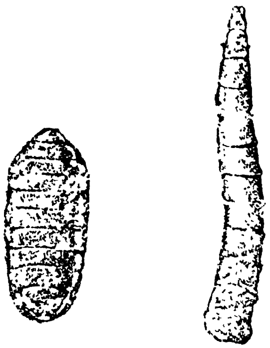

Fig. 102.
The Pupa and Larva of House-Fly.

1. *The Egg or Ovum.*—The eggs are glistening white, about $\frac{1}{25}$ in. to $\frac{1}{20}$ in. in length and look like tiny grains of polished rice under a fairly strong hand-lens. They are usually laid one on top of another. Each female lays from 120 to 150 eggs at a time and may deposit five or six such batches during its life. Thus each female may produce 600 to 900 eggs. The subsequent development depends upon the temperature of the air, and the character and the temperature of the food.

2. *The Larva or Maggot.*—The eggs hatch into tiny white, legless maggots within 8 to 24 hours. They grow rapidly and burrow into the food material on which they feed. They are about $\frac{1}{2}$ in. in length and develop within 2 to 4 or 5 days. The maggots shun the light and disappear during the day but come to the surface and move about at night. During the development of the larva it migrates to dry earth without which it cannot pupate. This is an important point which should be taken into account when considering measures for the prevention of breeding of flies.

3. *The Pupa or Chrysalis.*—The full grown maggot is followed by this stage which extends from 5 to 7 days under favourable conditions, but may extend to four weeks or more. It is passed within a barrel-shaped puparium or shell, usually about $\frac{1}{4}$ in. in length. It is at first of a pale yellow colour, but becomes successively red, brown and finally black.

4. *The Adult Fly.*—The newly hatched fly is lacking in colour, has a wizened or shrunken appearance and is

incapable of flying. It is provided with a sac on the front of its head which by alternate expansion and contraction helps the fly to escape from the puparium. The sac is subsequently withdrawn inside the head and cannot be seen any more. The wings spread out soon, the outer covering of the body and legs harden and the fly looks quite normal.

Excepting the important group of blood-sucking muscidæ, flies, as a rule, cannot bite, and therefore are not blood-suckers. They, therefore, act as carriers of disease in a purely mechanical way either through their fæces, vomit, legs, and other surfaces of the body. The infection remains 36 hours on the legs, 8 days in vomit, *i.e.*, in the proventriculus, and 18 days in fæces. It has been proved that the fly is capable of carrying *B. enteritidis* (Gaertner) for eight days; *B. prodigiosus* up to seventeen days; *B. tuberculosis*, when infected by feeding on tubercular sputum, for seven days; *B. anthracis* for five days, and spores for at least

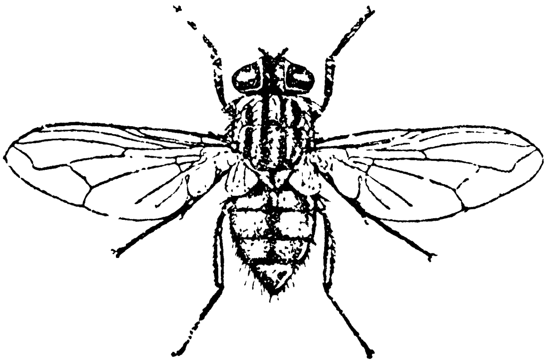

FIG. 103. THE HOUSE-FLY.

twenty days; and *B. diphtheriæ* for twenty-four hours. Cysts of *E. hystolitica* have been found in the fæces of flies twenty-four hours after a meal on infected fæces.

No method of sanitation is perfect that does not limit or destroy their breeding places, and also prevents or limits their access to excreta, and protects articles of food, both in public and private places, from their contact. The presence of flies indicates that there is abundant food or good material for the deposition or hatching of eggs in the vicinity.

Certain kinds of adult *Muscidæ* bite and suck the blood of man and animals. Their trunk undergoes transformation into a rigid tube of variable length which extends horizontally from the under-surface of the head and serves to pierce the skin. The most important of these biting flies are the *Stomoxys calcitrans*, which act as carriers of *Trypanosoma evansi*, causing *surra* in animals; the *Chrysops dimidiata* and *C. silacea*, which act as intermediary host of *Loa loa*; and the

tsetse fly which acts as the carrier of the parasite *trypanosome*, giving rise to sleeping sickness. It was formerly supposed that the parasites were conveyed in a purely mechanical way, carried in the insect's proboscis, but observations by Kleine and Bruce tend to prove that in addition to mechanical transmission, the glossina serves as an alternate host in a purely biological sense, and that the trypanosome, after entering the intestinal canal of the insect undergoes developmental changes which enable it subsequently when opportunity offers to effect a lodgment in some vertebral host.

The Stomoxys.—In appearance it resembles the domestic fly, from which it is distinguished by the horizontal rigid, shining black proboscis projecting like an awl in front of the head. It is non-retractile. The *Stomoxys calcitrans* is the common stable fly. It is found all the world over, living near stables and cattle-sheds. It can be identified by the eyes, kidney shape in profile, and the dark rounded spots in the form of a triangle on the abdominal segments. The palpi are short and not protecting the proboscis, and the wings diverge at an angle when resting. The fly is a very voracious blood-sucker and never quits inhabited places. The larvæ look like maggots. In the course of two to three weeks they change into pupæ which develop in a fortnight.

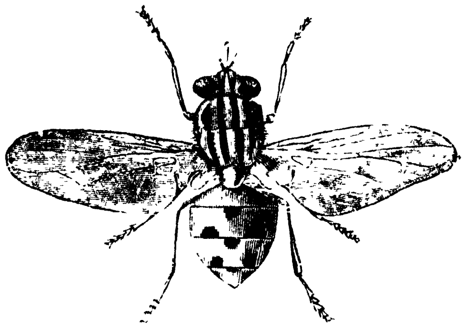

FIG. 104.—STOMOXYS CALCITRANS.

The Glossinæ.—The study of tsetse flies and the diseases disseminated by them is not only of scientific interest, but of great practical importance. This is evident from the fact that some thousands of the natives of Uganda have died from sleeping-sickness alone—a disease disseminated through the tsetse fly. Austen characterises the tsetse fly as follows :—

"Tsetse may be described as an ordinary looking sombre, brownish, or greyish or brown fly varying in length from 3½ to 4 lines in the case of *Glossina morsitans* to about 5½ lines in that of *Glossina fusca* or *longipennis*, with a prominent proboscis in all species. The hinder half of the body or abdomen in the best-known species, though not in all, is of a paler colour and marked with sharply defined dark brown bands which are interrupted in the middle line ; the abdomen, however, is invisible when the insect is at rest, as it is then concealed by the wings. The sexes can readily be distinguished since in the male the external genitalia form a conspicuous, knob-like protuberance (hypopygium) beneath the end of the

abdomen, which is absent in the females." When in a resting attitude the wings overlap on the back, crossing each other like the blades of a pair of scissors and project beyond the abdomen, and thus differ from stomoxys and the domestic fly. This not only gives the fly an elongated appearance, but serves to distinguish it from other blood-sucking diptera.

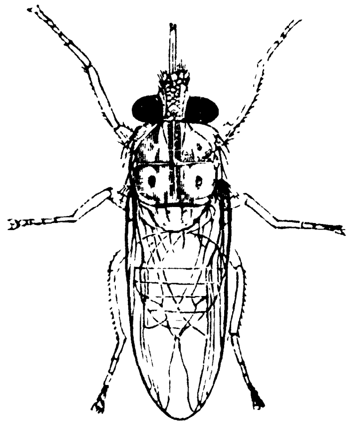

FIG. 105.—TSETSE FLY

Glossinæ do not lay eggs like most other flies; the larvæ attain their full growth in the ovary, and after being passed do not feed but pass into the ground and become pupæ. The larvæ are deposited in the vicinity of rotting vegetation, especially near the roots of plants and trees. *G. palpalis* is found in boats and canoes, and frequently it will crawl out and bite the legs; and as it flies low it often bites either the ankles or the legs, unlike the higher flying *G. morsitans*, which attacks the upper part of the body, the head or the neck. *G. palpalis* is the conveyer of *Trypanosoma gambiense*, while *G. morsitans* is the vector of *Trypanosoma rhodesiense*, the cause of Rhodesian type of sleeping-sickness.

Tsetse flies are confined to Africa and the shores of the Arabian Sea: they are found along the banks of rivers, springs, coasts of lakes, open pools, and sandy banks, especially at the foot of mountains. The tracts occupied by the flies are known as "fly belts."

Tsetse flies are voracious blood-suckers, exhibiting great persistency in their attacks on man and animals. They bite almost exclusively during the day. The bite is rather painful, and unless infected produces no subsequent local effects. The flies become infective about twenty to thirty days after feeding and remain infective for seventy to eighty days, and probably for the rest of their lives. In biting a patient suffering from sleeping-sickness it sucks up with the blood some of the trypanosomes which then undergo developmental changes within its gut. After certain changes in shape, multiplication and number the organisms find their way into the salivary glands, when opportunity offering they are injected to fresh individuals. Contrary to what is the case among horse-flies (*Tabanidæ*), *Simuliidæ*, and mosquitoes (*Culicidæ*), of which the female alone suck blood, in the tsetse both sexes are blood-suckers.

Besides these, certain larvæ of dipterous insects like screw-worm, or sarcophagidæ, cause myiasis in man. The

larvæ are deposited in open wounds and in the ear and nasal fossæ, especially of those having offensive discharges, which attract the fly. They fix and burrow in the tissues giving rise to pain and blood-poisoning which may end fatally.

Protection against Flies.—The fly should be regarded as a creature of disgusting and dangerous habits and should not be tolerated within the dwellings or on the food any more than a plague-stricken rat. Therefore every precaution should be taken to prevent the fly nuisance. The following golden rules advocated by Austen are worth remembering:—

1. "It is better to prevent house-flies from breeding than to permit them to breed unchecked and then endeavour to kill the resultant broods after they have invaded houses or other habitations."

2. "No system of sanitary control can be regarded as efficient which allows house-flies to have access to materials containing, or possibly containing the germs of disease."

A. *Measures against Eggs, Larvæ and Pupæ.*—Since flies breed in filth and dung or decayed animal or vegetable matter, measures should be taken to remove refuse, especially stable refuse, daily. Horse manure being the most favourable breeding ground, requires careful manipulation. The best method of disposal is of course by incineration. Where this is not possible, especially in dry weather, the manure could be dried in the sun in thin and even layers, which could be collected and burnt in heaps.

It is rather difficult to control breeding of flies in ordinary domestic manure heaps. But one can reduce the number by collecting and destroying the eggs or larvæ as advocated by Capt. Marrett. One way is to mark out the spots where flies are seen ovipositing and later to burn the cluster of eggs. Another method is to catch the larvæ in special traps during their migration to moist, cool spots suitable for pupation.

A large number of chemicals has been used and advocated to kill the maggots or eggs, but most of them have proved useless. Thus for the prevention of breeding in any material, *bleaching powder is absolutely useless.* A 5 p.c. solution of cresol, borax ($\frac{1}{2}$ lb. dissolved in 2 to 3 gallons of water) and powdered hellebore (*Veratrum viride*) however are quite useful. *These substances when applied in sufficient quantity prevent* hatching out of adult flies.

The most difficult part of an anti-fly campaign is educating the public to dispose of all household and kitchen refuse properly. No amount of screening, trapping, or poisoning will make up for careless disposal of filth and waste, which should be disposed of either by burning or by dumping. The *disposal of human excreta in a way that will prevent breeding of flies is of extreme difficulty. Unless fly proof buckets are* used and the night-soil is removed in well covered receptacles

it is impossible to prevent the fly nuisance. Disposal in shallow trenches often affords an excellent breeding ground and the larvæ hatched out in the excreta easily find their way to the surface. Deep trench latrines covered with fly-proof seats (*see* page 241) are more useful when properly managed. It is almost impossible to prevent breeding of flies in the latrines of private houses, where the pail contents are removed only once in 24 hours. If, however, each person using the latrine covers up his excreta completely with earth or sand it will prevent access of flies. Simple, though this precaution is, it is a matter of extreme difficulty to make people observe it in practice. Liberal use of crude oil is more efficacious.

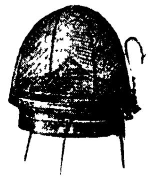

FIG. 106.
FLY TRAP.

B. *Measures against Adult Flies.*—In spite of precautions to prevent the breeding of flies there will still be flies and to spare. These measures are, therefore, used for the destruction of the adult house-flies.

Flies are killed in many ways, by adhesive fly-papers, fly-traps, poisons, spraying fluids, petrol fumes and fly-killers.

The usual poisons are formalin, sodium arsenite and pyrethrum powder. A poison, harmless to man, is made by mixing together one dessert spoonful of commercial formalin with one pint of lime water. A little sugar, honey or treacle may be added. This mixture is put in a cup or tray and then placed in kitchens, dining rooms, etc. To be effective no other food should be accessible to flies. Sodium arsenite is a powerful poison and should be used with caution. It can be used on a small scale indoors or may be sprayed on to manure heaps. Leafy branches may be soaked with the solution and suspended in the vicinity of latrines and other places where flies congregate. Usually $15\frac{1}{4}$ grs. of sodium arsenite is dissolved in $3\frac{1}{2}$ oz. of water to which a little sugar or *gur* is added. In the form of spray or fume this solution is very useful in killing flies in huts, tents, buildings, etc., in the evening after the flies have settled down for the night.

Fly papers or "tangle foot" are made by heating together five parts of castor oil and eight parts of resin powder and then spreading in thin layers on glazed paper. This is effective as long as it remains "tacky."

Fly traps are very useful in destroying adult flies and several varieties are now obtainable. A very convenient form has been devised by Col. Balfour in which the flies enter through a narrow slit on the side and once inside they seldom find their way out. These are subsequently killed by fumigation. An ordinary trap consists of an outer cone or cylinder of wire gauze with an inner cone of the same material having an opening at the point and

supported on short legs. The trap is baited with stale eggs, spoiled banana, or *gur* (treacle). The flies seek the bait and enter the larger cone through the opening in the inner one and are unable to find their way back. The small traps are intended for indoor use, and the large ones are placed outside on the street.

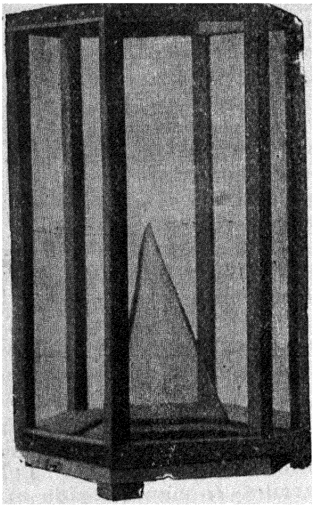

FIG. 107.—FLY TRAP.

PULICIDÆ OR FLEAS

Fleas belong to the order of *Siphonaptera*, and they differ from other insects in not possessing any wings and in having a form and structure profoundly modified in consequence of their parasitic habits. They have a body flattened laterally consisting of head, thorax, and abdomen. The head is united behind to the thorax. The limbs are long and spiny, and the foot has five joints, which end in hooklike processes called claws turned in opposite directions. The anterior limbs are inserted nearly underneath the head and are more slender than the posterior ones. "The beak is composed of an exterior jointed sheath, having inside it a tube, and carrying underneath two long sharp lancets, with cutting and sawlike edges. It is with this instrument that the flea pierces the skin, and both males and females suck the blood."

The relation between different species of flea and their host is not a close one. In the absence of the host the flea will feed on the blood of other hosts, which may be of the allied species or entirely different. Thus in North China, *Pulex irritans* normally lives on the blood of the dogs but in the absence of dogs bites man. In Madras, *Ctenocephalus felis* will attack man, although it is the common flea of cat and dog. Similarly the plague flea, *Xenopsylla cheopis*, will readily bite man in the absence of its normal host, the black or brown rat. This power of adaptability to live on the blood of man in the absence of its normal host, the rat, makes the flea a powerful transmitter of the plague bacillus from rat to man.

The males are distinguished from the females by being smaller and having abruptly uptilted tails formed by the end of claspers and by the large coiled-up penis. The females

have no up-tilted tails but possess a curved receptaculum seminis which stands up prominently in any properly prepared specimen. The female flea lays eggs which are oval, smooth and white; and about eight to twelve are laid on floors, dirty carpets, or dry earth. They also pass through larval and pupal stages. It takes about two to four days in summer and eleven days in winter for the larvæ to come out of the eggs. The duration may be longer in winter and may be even 21 days. The larva is an active legless maggot with scanty hairs on every segment of the body. They can be detected with some difficulty in the dust where domestic animals sleep. When full grown they spin a cocoon usually covered with dust and dirt in which they are transformed into pupæ. In another fortnight they become perfect insects. They are most common in dirty and deserted houses, and in places inhabited by people of unclean habits. Several species live on animals, but the study of the rat-flea is of special interest to us.

FIG. 108. XENOPSYLLA CHEOPIS.

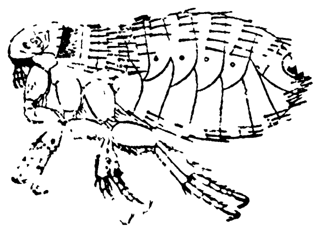

FIG. 109. CTENOCEPHALUS CANIS.

Rat-flea.—*Xenopsylla cheopis* is the common rat-flea of India and of the tropics, and acts as the passive intermediary carrier of *B. pestis*, not only from rat to rat, but from rat or other infected animals to man. Besides the rat-fleas other species of fleas, as for instance, *Ctenocephalus canis*, which bite dog, rat and man also act as carriers of plague. Fleas act not only as carriers, but also as multipliers of the germs. It has also been shown by the experiments of the Indian Plague Commission that if fleas are excluded, healthy rats will not contract the disease even if kept in contact with plague-infected rats. It resembles very much the common flea, *Pulex irritans*, but it is smaller and light coloured and has a number of bristles on the head.

Three distinct species of *Xenopsylla* are found in India, *viz.*—*X. cheopis*, *X. astia*, and *X. braziliensis*. Hirst has pointed out that the rats of Colombo and Madras being exclusively

infested with *X. astia*, these cities are free from plague, and attributed this to the relative inefficiency of *X. astia* as a carrier of plague both from rat to rat and from rat to man. He, however, holds that both *cheopis* and *astia* will carry the virus of plague, but that under similar conditions the *cheopis* is a more efficient vector than the *astia*. He pointed out that *X. astia* bites man with reluctance under tropical conditions, especially when the temperature is over 80° F., and *X. braziliensis* does not readily bite man at all. Cragg as a result of flea survey on the Indian rats concluded that the distribution of plague was closely correlated with the prevalence of *X. cheopis*. Taylor and Chitre, however, hold that *X. astia* is capable of transmitting plague to rats under suitable climatic conditions, but that it may be a somewhat less efficient vector of plague than *cheopis*. Of both the species the males carry plague to rats more readily than the respective females. Goyle, as a result of experiments on the transmission of plague supports the view of Hirst and maintains that transmission of plague by *cheopis* does not occur at a saturation deficiency of 0.6 of an inch accompanied by a temperature of 68° F. At the same temperature a lower degree of saturation deficiency of 0.3 of an inch suffices to check *astia* from carrying plague. By saturation deficiency is meant "the difference between the actual tension of aqueous vapour present in the atmosphere at the temperature in question, and the tension of aqueous vapour that would be present in a saturated atmosphere at the same temperature." The saturation deficiency is thus a measure of the drying capacity of the air, a high degree of which is prejudicial to the life of fleas.

Trypanosoma lewisi is also transmitted by rat-fleas. It undergoes development in *X. cheopis* and *Ceratophyllus fasciatus* and other fleas. But the rat-flea is the chief carrier. The infecting material is found in the fæces. Infection takes place by the licking of fæces of an infected flea by the rat.

Sandflea or Chigger.—*Tunga (Sarcopsylla) penetrans* is a troublesome insect found in the West Indies and coasts of Africa. It lives on the ground, and is abundant in very sandy soil particularly near the sea shore. Dirty rooms and huts, stables for cattle, etc., are the favourite haunts of these insects.

The chigger resembles the common flea, but is a little smaller, the head being comparatively larger. It is flat, reddish brown in colour, and attacks all warm-blooded animals including birds and man. It is armed with a powerful rostrum, a prolongation of the pharynx—the epipharynx. The under surface is grooved and continuous with the wall of the pharynx. The mandibles are also grooved on the mesial surface. Being nearest the ground, the feet are the parts most commonly attacked by chiggers. The scrotum, penis,

the parts round the anus, the thighs, the head and face may also be attacked.

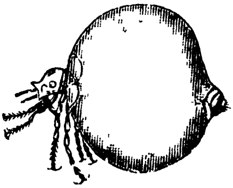

FIG. 110.
SANDFLEA; IMPREGNATED FEMALE.

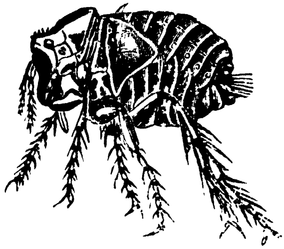

FIG. 111
SANDFLEA.

The female, when impregnated, makes her way under the skin and becomes almost a motionless bladder through the enormous development of the ovary. During this period it sets up much irritation with inflammation and formation of pus which gives the appearance of a pea-like elevation. When the chigger is expelled a small sore is left behind. These insects are responsible for causing suffering, invaliding, and indirectly death.

The common sources of fleas in a house are (*a*) want of proper cleanliness; (*b*) proximity of stables, where fleas breed; and (*c*) flea carriers, *viz.* cats, dogs, rats, etc.

Preventive Measures.—Rats and mice must be got rid of. Dogs and cats require careful washing with soap and carbolic acid or some other coal-tar preparation. Badly infested rooms should be thoroughly washed after sprinkling flaked naphthalene over the floor and keeping it shut for 24 hours. Petroleum, kerosene, or paraffin oil emulsion with soap will kill fleas on the floor, clothing, or on the coats of animals.

BUGS

Bed-bug.—It is a flat, oval and on closer examination a bristly little creature, 5 mm. ($\frac{1}{4}$ of an inch) long and 3 mm. broad, of a dull amber or chestnut brown colour. The head is short and broad with a pair of prominent compound eyes and two antennæ or "feelers". On the lower side of the head is the apparatus with which it sucks blood. The segmented rostrum or proboscis runs backwards from the front part of the head to between the bases of the first pair of legs.

It belongs to the order of Hemiptera and comprises an enormous number of species. In India two species, *Acanthia lectularius* (*Cimex lectularius*) and *A. rotundatus*, attack man. It has a very wide distribution and can survive long periods—even a year—without food (Lefroy). The eggs are

laid in any place to which the females can gain access—in cracks and fissures, in furniture, etc. Like a mosquito it

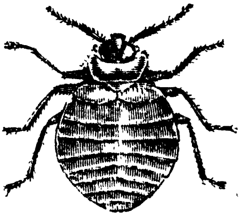

FIG. 112.
THE BED-BUG (Dorsal view.)

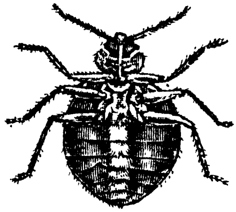

FIG. 113.
THE BED-BUG (Ventral view).

injects an irritating fluid which causes a flow of blood to the spot on which it engorges itself.

The bed-bug has been suspected of transmitting several diseases, including kala-azar, but it cannot be said that the case has been proved against it in respect of any of the diseases.

Although they cannot fly, bed-bugs walk rapidly and are capable of migrating from one house to another. They are frequently introduced with luggage, boxes, etc., and are usually found in cracks and crevices of all kinds, in wood-work, walls, floors, amongst books, etc., and frequently near a bed and in the frame work of the bed itself. They are also common in chairs, railway carriages, tram cars, etc.

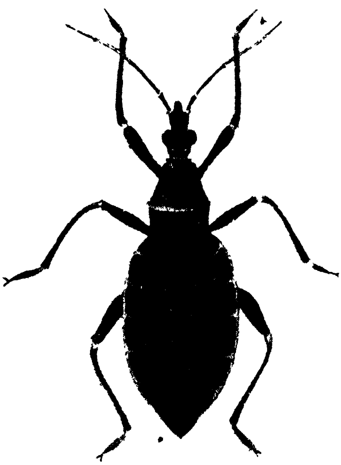

FIG. 114.—ADULT CONORHINUS.

On account of their habits bed-bugs are very troublesome to exterminate. Liberal application of gasoline, benzene, or kerosene oil emulsified with soap, is often helpful. Fumigation with hydrocyanic acid, sulphur dioxide and formaldehyde is often resorted to in railway carriages and buildings. Superheated steam may be tried. The use of boiling water, where there is no possibility of damaging the articles, is very effectual in destroying both the eggs and the bugs.

Ammonia, olive oil, or menthol are said to allay the irritation caused by the bites. Tr. iodine and peroxide of hydrogen have also been used with good results.

Conorhinus.—This belongs to the family *Reduviidæ* and

has of late attracted much attention. Thus *Triatoma* (*Conorhinus*) *megista* is held responsible for transmitting human trypanosomiasis in some parts of Brazil where it is called "barbeiro" on account of its preference for biting the face; while in India some believe that *Conorhinus rubrofasciata* is the likely invertebrate host of the protozoon bodies of kala-azar. But recent experiments by the Kala-azar Commission have shown that the development of the parasite of kala-azar does not take place in this insect.

These are black insects with red markings on wings, abdomen and prothorax and are one inch or more in length, dark brown in colour. They are purely domestic insects, nocturnal in habits and are generally found near bright lights which have an attraction for them.

The exact breeding places of these bugs have not yet been discovered, but it appears that they lay eggs on trees, rat holes, cracks and crevices. The nymphs, which cannot fly, crawl out of these spaces and make their way in search of mammalian blood and convey the infection. It takes about 5 to 6 months for the eggs to develop into the adult stage, passing through five intermediate stages and after each stage is completed a cast off skin is left behind.

TICKS

Ticks as a class of ectoparasites are most abundant in warm countries. This is ascribed to the fact that cold is unfavourable to the requirements of the egg and all the stages in early life. They form a very important class of blood-suckers and play an important part in the transmission of a disease, closely simulating the relapsing or famine fever of India. They attack all types of terrestrial vertebrates, most mammalia, the aves, some reptilia and amphibia. The ticks are sufficiently big to be seen by the naked eye, and the females are usually larger than the males. As a rule they are temporary parasites. Ticks differ from insects in possessing four pairs of legs, only two pairs of mouth-parts, no antennæ, and in having the head, thorax and abodmen fused into one unarticulated mass.

The female tick lays five thousand eggs at a sitting, but only a few of these have any chance of attaining maturity; it then dwindles up and dies within a few days. The eggs are small grains of a yellowish colour, and in two or three weeks' time they are hatched, giving rise to larvæ which look like minute moving grains of sand, and are characterised by having six legs, no stigma, and no sexual organ. They pass through a series of moults as they grow from minute larvæ to sexually mature adults, and at each feed they fall to the ground and after moulting have to find the right host if development is to be continued. After a short period of

rest the larvæ seek food; they swarm up to the tips of the blades of grass and await in clusters their warm-blooded host. They then become gorged with the blood of the host and

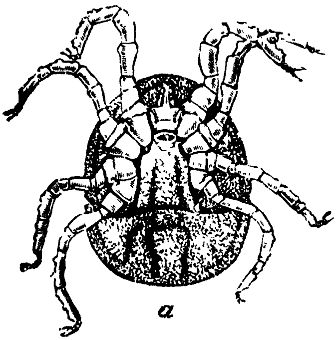

FIG. 115.
ORNITHODORUS MOUBATA
(Ventral Aspect).

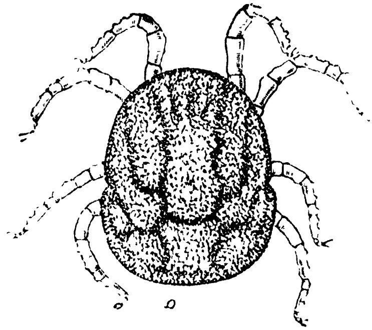

FIG. 116.
ORNITHODORUS MOUBATA
(Dorsal Aspect).

pass through their first moult and emerge through the larva skin as nymphs. The nymph presents four pairs of legs, but still no sexual organs. Like the larva, it moves about until it attaches itself to some warm-blooded host and then drops off to moult again, when it becomes sexually mature. Having thus reached maturity the sexes unite. After fertilization the male dies while the female proceeds to feed on the blood of her host for the development of her ova.

On account of the difficulty of finding a suitable host ticks at all stages are endowed with a phenomenal capacity for fasting. In fact they have been found alive after a fast of four years' duration (Manson).

Ticks are nocturnal in their habits, like bed-bugs, and live in huts, cracks and crevices in the walls, floors, or in thatch or reeds of which the roof and walls are composed. They are frequently carried in mats or bedding, or in porters' loads which have been stored in rest huts at night.

Breeding of ticks in the laboratory is not so easy. A complete knowledge of their bionomics is necessary before any attempt could be made, since success depends entirely on a thorough understanding of the life-history and the habits in the early stages. Thus, the whole life-cycle from the egg to sexually mature adult stage may be completed in one species of host, or the successive stages may feed on another species.

The fact that the tick remains fixed on to the skin of an animal does not necessarily mean that it is feeding on the host. While some species remain fixed on to the skin of animals, others drop off after a feed of blood. Copulation usually takes place on the skin of the host.

Mollers showed that *Ornithodorus moubata* may remain infected for one and a half years, and that once infected with spirochætes, they continued to infect the third generation

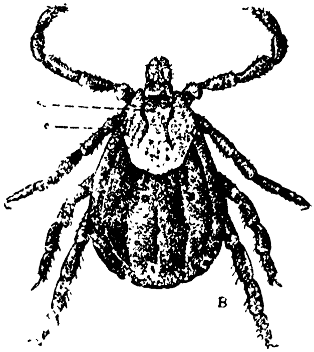

FIG. 117.
DERMACENTOR VENUSTUS. (Dorsal view) e., eye: sc., Scutum.

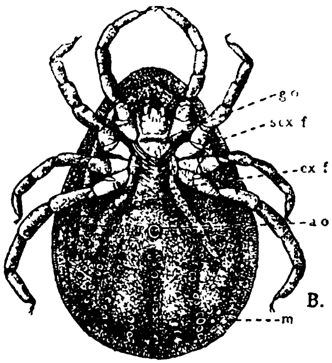

FIG. 118.
ARGAS PERSICUS (Ventral view) a. o., anal opening; cx. f., coxa fold; m, margin of body; g. o., genital opening; scx. f.; supracoxal fold.

through the ova. They transmit *Treponema duttoni*, the causative organism of African relapsing fever; *Dermacentor venustus* transmits the organism for Rocky Mountain spotted fever; and it is suspected that the Indian typhus is conveyed by *Rhipicephalus sanguineus* or *Hyalomma ægyptum*; while *Trombicula akamushi* carry the virus of Japanese river fever, known as Kedani or *Tsutsugamushi disease.* It is believed that the hereditary infection of tick through many generations, helps to maintain the disease without fresh infection from a mammal. Tick paralysis follows the bite of certain ticks, chiefly *D. venustus*, and is found in Cape Colony, British Columbia, United States and Australia. *Argas persicus* is not known to transmit any disease to men but transmits *Treponema* of fowl spirochætosis.

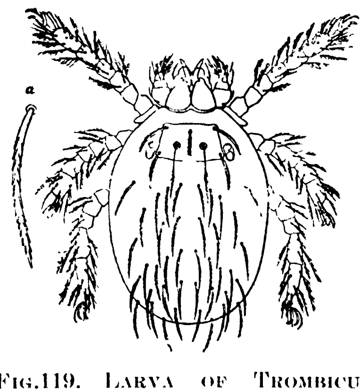

FIG. 119. LARVA OF TROMBICULA AKAMUSHI. *a.* One of the dorsal bristles enlarged.

Destruction of ticks is a difficult matter. Mud floors, reed and thatched walls and roofs cannot be thoroughly cleaned.

While travelling, huts should be avoided. *O. moubata* cannot climb up a smooth wall. Bedding should not be placed on the floors, and should always be carried in a tin box. There is little risk in the day time or when the rooms are lighted.

Ticks in animals are controlled by dipping in a solution of sodium carbonate 24 lbs.; acid arsenious 8 lbs.; tar 2 gals.; water q.s. to 500 gals. Crude petroleum has been used largely. The cattle may be treated by applying the above mixture by means of spray.

LICE

Lice are small wingless insects living entirely on mammalian blood. The whole life-cycle of the louse is bound up with that of the host. Three varieties of pediculus are parasitic on man, *viz.*, (*a*) *Pediculus capitis*, or head louse; (*b*) *Pediculus humanus corporis*, or body louse; and (*c*) *Phthirus pubis*, or crab or pubic louse. It is possible that other mammalian lice may temporarily infest man.

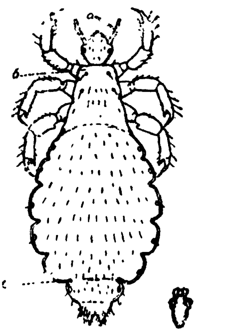

FIG. 120.—THE BODY LOUSE (Female)

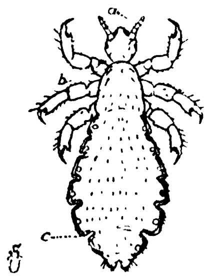

FIG. 121.—THE HEAD LOUSE (Female) *a*, antenna; *b*, width of body behind neck; *c*, depth of the clefts between the segments.

FIG. 122. THE CRAB LOUSE.

The head and body lice resemble each other so much that they cannot be distinguished by any single character. On the other hand the typical ones are quite distinct. The head is conical with a constriction where it joins the thorax, and provided with a proboscis, a pair of jointed antennæ and a compound lateral eye. The head louse is generally darker, smaller and more bristly. The colour of the adult louse varies according to the colour of the hair of the host. The male is smaller and rounded off posteriorly with a dorsal aperture for a pointed penis. The female is recognised by the larger size (2 mm. in length), and by a deep notch at the apex of the last abdominal segment. The eggs are deposited on the hairs of the host and hatch out in six days and begin to feed shortly after hatching. They become adult

in ten days. The antennæ are thicker and the abdominal division is deeply cut. The body louse is paler, larger, with slender antennæ, and the notch of the abdomen merely undulated. The head is olive shaped and more pointed anteriorly. It is separated from the thorax by a narrow neck.

The eggs hatch out in seven to ten days and become mature in about two weeks. In each of the three varieties there are three pairs of jointed legs terminating in claws. The surface of the limbs, thorax and abdomen is provided with scattered hairs. In length they vary from 1 to 4 mm.

The Crab Louse.—This is easily distinguished by the small size, square body, blunt and truncated head, relatively large and strongly developed legs, prominent breathing apertures, and extreme inertness. They are generally found in the pubic and perineal hairs, and occasionally among the eye lashes. In fact, they are found on any part of the body where the hair is suitable, excepting the head where it finds some difficulty in holding.

The female lays up to 300 eggs, from 8-12 a day, usually deposited either on hair, or on cloth; they are $\frac{1}{25}$ in. long and $\frac{1}{60}$ in. broad. At one end of the egg is the operculum which opens and may be removed at the hatching of the larva. Between the egg and the adult stage a louse moults its skin three times, generally at an interval of 2 to 4 days. The whole process of development from the laying of the eggs to the adult louse may take about a fortnight.

Dissemination of Lice.—Contact is the determining condition of their dissemination. Lice neither arise from filth and dirt, nor spontaneously. Dirty habits favour the increase of lice if once they get a foothold. Head lice pass from unclean servants to the child, or in school from one scholar to another. They may be spread by brushes, hats kept in close proximity, clothing of lousy subjects, and an infested bed occupied by a clean person. They may be blown about by a high wind, and heavily infested persons often drop lice which may cling to benches, floors, carpets, etc. Dogs sometimes carry human lice from person to person. Head lice are common in women and children, body and crab lice in men. All three varieties may exist on one person.

Lice act as carriers of typhus fever, relapsing fever and trench fever. The fæces of lice, which have fed 2 to 6 days previously on a typhus patient are also infective. Both the crushed contents of the louse and its fæces can infect through the smallest skin lesion and possibly through the unbroken skin. Infection of relapsing fever takes place when lice are crushed either directly on the skin or between the nails of the thumb, when the spirochætes in the splashed blood find their way through the smallest abrasion on the skin. The excreta are not infective in this case nor is the infection acquired by the bite. The viruses of these diseases undergo developmental

changes in the louse, since it is incapable of transmitting the disease until several days after, *e.g.*, typhus fever, ten days; relapsing fever, four days; and trench fever, after seven days. Irritation caused by the bite often leads to pustular dermatitis and a form of pigmentation of the skin (Vagabond's disease).

Prevention of Lousiness.—

1. Regular washing of under-clothing and bed linen. These measures alone will prevent lice to thrive even if casual infestation occur.

2. Since most infestations are from personal contact one should avoid coming in contact with a verminous person. Do not introduce lice into the house.

3. Those coming in contact with infested persons, *e.g.*, nurses, should wear linen overalls. Undergarments may with advantage be impregnated with some insecticide.

The following treatment is necessary for those who have already got infested:—

1. A hot bath with a complete change of clothing followed by thorough disinfection of all garments.

2. The hair should be cut short. This is often sufficient when shaving is not possible, as with girls or women. Some insecticide may be first applied, *e.g.*, ammoniated mercury ointment 5 p.c. once a day, or calomel pomade (1 in 20 of vaseline) followed by brushing with a fine-toothed metallic comb previously warmed. Vinegar and kerosene oil may also be used. First saturate the hair with the oil and then wash. Instead of using vaseline which causes matting of the hair besides being messy, a 1 p.c. suspension in agar of yellow oxide of mercury is now available as "Lausin." After heating it to 100° C. to melt the agar, the whole is shaken to ensure uniform suspension and cooled to 50° C. and applied to the hair with a brush followed by the use of fine comb so that the agar coats each hair and dries thus. After 24 hours the lice are dead, and by washing and using 5 p.c. soda solution the nits are easily removed with a fine comb.

3. *Disinfection of Clothing and Bedding.*—This may be done by (*a*) *steam*, this is very useful when used in any steam disinfector. A convenient method of applying steam is by the use of "Serbian Barrel"; (*b*) *hot water*; (*c*) *naphthalene*; a small handful of flaked naphthalene scattered evenly between the blankets is often very effective; and (*d*) *hot iron*; this is an effective method of delousing clothes.

The clothes should be removed on a clean floor and not on articles where the pest or its eggs can lodge.

4. *Insecticides.*—Kerosene or petrol is very effective for nits, especially when mixed with some essential oil, *e.g.*, oil of sassafras, oil of eucalyptus, cedar wood oil, tar oil, etc. Lysol, carbolic acid and naphthalene are also good.

CHAPTER XVIII

ANIMAL PARASITES

ALTHOUGH parasites belong both to the animal and vegetable kingdoms, only the animal parasites will be discussed here. Of the animal parasites which affect human beings some are external and some internal. The former belong to the class of insects (which see) and the various acari, the latter include the worms and a variety of protozoa.

Parasitic animals are those which, in order to obtain their nourishment, live within or upon another living organism, known as their host. True parasites nourish themselves on the living material, *e.g.*, the blood or lymph of their host; saprophytic parasites derive their nutriment from dead material. Many parasites are pathogenic, and although some saprophytes do not harm their hosts, it is doubtful if the animal parasites are ever "symbiotic" *i.e.*, whether any are beneficial to their host.

Some parasites are found in different species of animals, *e.g.*, *Trichinella spiralis*, whilst others are limited to a single species, *e.g.*, *Ascaris lumbricoides* and *Oxyuris* (*Enterobius*) *vermicularis* are parasitic only on man. The anatomical situation of the parasites is known as its habitat, and they are designated *ectozoa* or *entozoa* according as they live upon or within their host.

The mode of reproduction within the body of the host is both interesting and varied. Some—the protozoa—produce successive generations within the host: others, *e.g.*, some worms, when within the host merely attain sexual maturity, and give origin to a second generation which, however, does not attain sexual maturity in the same host. In other instances two specifically different hosts are necessary for completion of the life-cycle of the parasite, which is immature in the one and sexually mature in the other. In the latter instance a change or alteration of the host is necessary for the developmental cycle of the parasite, and the animal in which the sexual cycle takes place is the *definitive host*; that harbouring the immature parasite is the *intermediate host*.

There are various ways in which man may be infected; the most common mode being the ingestion of eggs or immature forms of parasites together with water or other fresh food. By the ingestion of eggs man is infected with *Ascaris lumbricoides*, *Oxyuris* (*Enterobius*) *vermicularis*, *Trichocephalus dispar* and occasionally with *Cysticercus cellulosæ*; by the ingestion of immature species man is infected with *Ancylostoma duodenale* and *Trematodes*. Again, infection may occur from

the ingestion of the immature parasite in an intermediate host. It is in this way that man becomes infected with adult *Cestodes* and *Trichinella spiralis*. Finally, parasites may be transmitted by the direct agency of the second host, *e.g.*, *Filaria*.

Effects of Parasites.—The animal parasites may cause disease in a variety of ways:—

1. By mechanical injury.
2. By producing inflammatory reaction in the tissues.
3. By withdrawal of nutrient material.
4. By removal of blood.
5. By production of toxins.

TREMATODES OR FLUKES

1. **Schistosomidæ (Blood Flukes).**—Three species of these worms are known to occur in man, *viz.*, *S. hæmatobium*, *S. mansoni*, and *S. japonicum*. The life-history of the three varieties is more or less the same, therefore a description of *S. hæmatobium* will apply to all, only their differential characters will be given in a tabular form.

Schistosoma (Bilharzia) hæmatobium.—This worm gives rise to a chronic disease characterised by cystitis, hæmaturia and other symptoms due to blockage of the urinary passages producing a papillomatous growth, a condition known as *Bilharziasis*. It is common in Africa. Endemic foci also exist in Palestine, Mesopotamia, Arabia and Cyprus. It is also found in Western Australia. The males are narrow, flat or leaf-like worms, and look cylindrical from the folding in of the sides of the skin forming the gynæcophoric canal where the female is partially enclosed. They are white or grey in colour, 1.1 to 1.5 cm. long, and 1 mm. broad, narrow anteriorly with two suckers placed close together; posteriorly blunt and rounded. The female is cylindrical, longer (1 cm. by 0.25 mm.), more filiform and darker than the male. Both ends are tapering. The body, unlike the male, which is studded with small cuticular prominences, is smooth with *numerous papillæ towards the posterior end.*

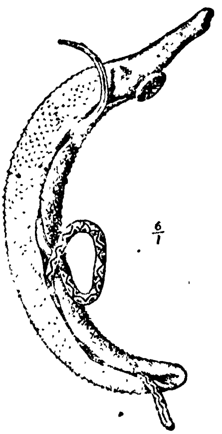

FIG. 123.
SCHISTOSOMA MANSONI. Male and Female. (After Looss).

The *eggs* are oval or spindle-shaped with a stout spine at the posterior end. The ova are deposited in the venules with the spines pointing in the direction of the blood current. These eggs are forced through the vessel walls and eventually appear in the *bladder* or rectum, and escape either through the urine or the fæces as the case may be. If the egg after

being expelled comes in contact with a fluid of lower osmotic pressure the shell membrane and chitinous cuticle swell up and burst setting free a ciliated embryo or *miracidium.*

The *miracidium* is slightly smaller than the ovum, and thickly covered with cilium by means of which it moves about and seeks its intermediate host, *viz.*, spiral fresh-water *molluscs*, where it undergoes a series of changes first forming a *sporocyst* and then a *cercaria*, and eventually comes out through the pulmonary chamber of the snail into the surrounding water. The cercariæ are white thread-like bodies which move about 24 to 36 hours after emergence from the snail and if they find a suitable definitive host (usually man) they cast the tail and piercing the epithelium enter the deeper tissues. They enter the veins and eventually the liver and tributaries of the portal vein, where they gradually develop and become differentiated into two sexes and complete the sexual cycle of their development. They are able to pass through a perfectly sound skin in a few seconds and therefore any one bathing or even putting an arm into the water infected by these organisms may easily become infected.

Schistosoma mansoni.—It is common in Africa being abundant in Egypt, the Congo and French West Africa. It is also common in parts of South America, and inhabits the branches of the portal vien in the liver, and the mesenteric viens, and gives rise to symptoms of dysentery and a peculiar form of cirrhosis of the liver. In the early stage there is pyrexia and urticaria, indicating absorption of the toxins excreted by the adult parasites, and is followed by a condition known as *Intestinal Schistosomiasis.* A form of splenomegaly known as *Egyptian splenomegaly* with cirrhosis of the liver and ascites, possessing features resembling infantile kala-azar also occurs as a complication.

Schistosoma japonicum.—It is common in parts of Japan, China, Upper Burma and the Philippine Islands, and is confined to rice growing regions where the conditions favourable for the life-cycle of these worms occur, *viz.*, flat, low-lying, freely watered country, abundance of intermediate host and ready accessibility of the definitive host. These worms enter the skin through the sweat glands and the hair follicles whence the cercariæ pass into the lymphatic and smaller blood vessels and then into the general circulation and finally into the portal vessels. They cause enlargement ot the spleen and liver with ascites. The ova are expelled with the stools. These flukes differ from the other two species in being smaller in size and having no tuberculations on the integument.

The disease is known as Katayama disease on account of its prevalence in the district of that name in Japan.

The differences of the morphological characters of the three species are given in the following table* :—

	S. H.	S. M.	S. J.
Male	1.5 cm. long, 1 mm. broad.	1 cm. long, 1.2 mm. broad.	0.9 cm. long, 0.6 mm. broad.
	Finely tuberculated. Testes 4, large, posterior and dorsal to ventral sucker.	Grossly tuberculated. Testes 8, small, posterior and dorsal to ventral sucker which is more prominent.	Not tuberculated. Testes 8, elliptical, posterior and, dorsal to ventral sucker.
Female	2 cm. long, 0.2 mm. broad.	1.1 cm. long, 0.16 mm. broad.	1.2 cm. long, 0.4 mm. broad.
	Ovary in posterior third in front of intestinal cæca.	Ovary in anterior half of body in front of union of intestinal cæca.	Ovary in middle of body. May contain 300 ripe ova.
	Large no. of terminal spined eggs	*Eggs 1 or 3, lateral spined, with spine directed posteriorly.	Eggs with lateral knobs
	Yolk glands distributed in posterior fourth of body.	Yolk glands widely distributed in posterior half of body	Yolk glands well developed Occupy posterior half of body.

Prophylaxis.—In places where the disease is common one should avoid drinking or bathing in rivers, tanks, etc. The water for drinking purposes should either be boiled or filtered after having strained through cloth to remove water snails. Allow the water to stand for 48 hours before using, as any free cercaria, not being able to complete its life-cycle, would die if it cannot gain access to a man. Contamination of the water with infected urine or fæces should be prevented. Copper sulphate in strength of 1 in 5,000,000 may be used to kill the snails. Case reduction may be secured by treating all infected persons with tartar emetic; the usual method being to begin with 0.5 gr. intravenously and working up slowly to 2 to 2.5 gr.; the total quantity required being 20 to 25 grs. spread over 4 to 6 weeks. Emetine may also be used.

2. **Fasciolopsis buskii (Intestinal Fluke).**—This intestinal fluke is common in Assam, Straits Settlements, Sumatra, Borneo and Cochin-China. It lives in the small

*Byam and Archibald, *Practice of Medicine in the Tropics.*

itestine of man and gives rise to gastro-intestinal disturb-nces. The pig is the normal host or reservoir. It is 30 mm. ong, 12 mm. broad and 2 mm. thick, and is the largest trema-ode parasite of man. It is a thick, flesh-coloured fluke of an longated oval shape, the ventral surface being covered vith spines arranged in transverse rows. It possesses two uckers, one terminal, the other adjacent to it and situated entrally.

The *life-cycle* resembles that of *Fasciola hepatica* (*Dis-omum hepaticum*). The embroyo undergoes transformations n certain molluscs, species of *Planorbis* and *Segmentina*, vhich serve as intermediate hosts. The cercariae, on becoming ree in the water, encyst on fresh-water plants, specially the vater chestnut, which, when consumed raw, convey the in-'ection to man.

3. Gastrodiscoides hominis (Intestinal Fluke).—This luke is found in India (Assam), Cochin China, Federated Malay States and also in British Guiana. It is found in the caecum nd large intestine of pig and in some cases the mouse deer. When fresh it is reddish in colour and is generally 5-7 mm. ong and 3-9 mm. broad with a teat-like projection bearing n oral sucker. The body is divided into an anterior conical

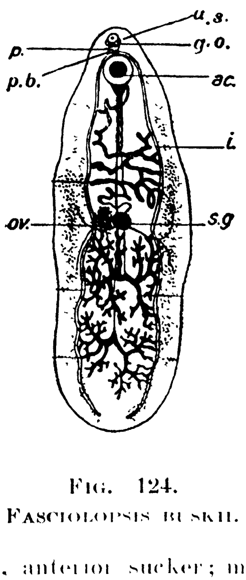

Fig. 124.
Fasciolopsis buskii.

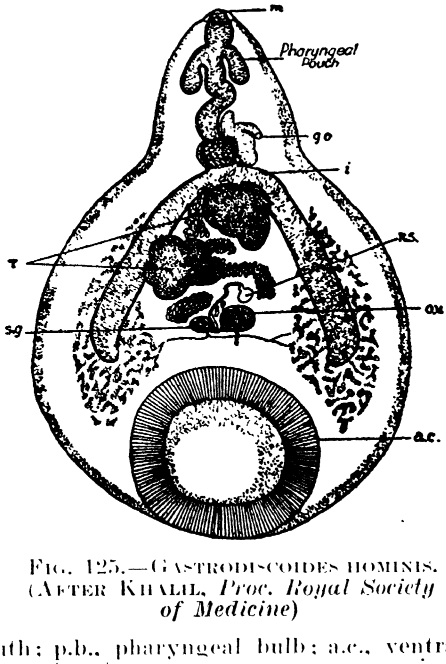

Fig. 125.—Gastrodiscoides hominis. (After Khalil, *Proc. Royal Society of Medicine*)

s., anterior sucker; m, mouth; p.b., pharyngeal bulb; a.c., ventral ucker; g.o., genital opening; u.t., uterus; o.v., ovary; va, vagina; s., vesiculis eminalis; t, testis; v d., vas deferens; i, intestine; ex. p., xcretory pore; s g., shell gland; R. S., receptaculum seminis

and a posterior discoidal portion forming a ventrally concave flattened disc. The acetabulum is in the posterior of the disc, circular and 2 mm. in diameter. The cuticle is smooth. It causes symptoms of dysentery in infected man. These flukes are expelled by thymol.

4. **Clonorchis sinensis (Liver Fluke).**—It is a common parasite of man in the Far East including Japan, Korea, Formosa, Mauritius and India. In China dog and cat are naturally infected with this parasite It lives in the biliary passages causing enlargement of the liver, diarrhœa, jaundice, anasarca and even death The fluke is 10-20 mm. long and 2-5 mm. broad, oblong in shape, reddish in colour, flat

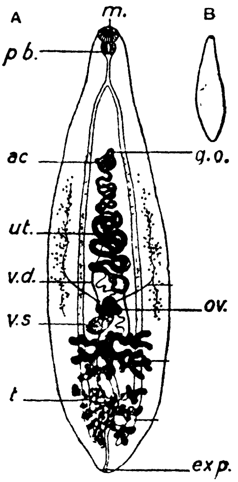

FIG. 126. CLONORCHIS SINENSIS (After Looss.)

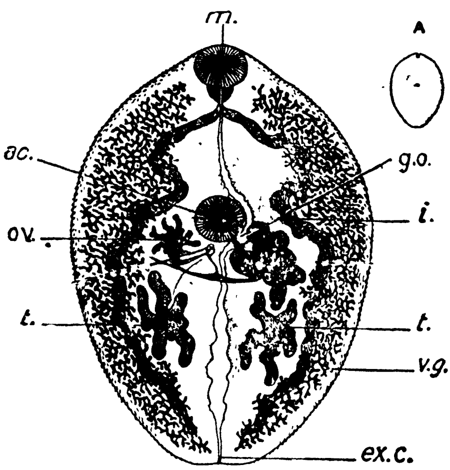

FIG. 127. PARAGONIMUS RINGERI (Partly after Looss)

(For lettering, *see* under figure 124).

and pointed anteriorly. Its primary host is a gastropod *Bythinia striatula*. The cercaria escaping from the molusc enters the secondary host which is a fresh-water fish of the carp family where it gets encysted. When this fish is consumed half cooked the young clonorchis enters the human gut eventually reaching the bile duct.

Prevention depends upon proper cooking of the fish and protecting the water supply by preventing man and animals harbouring the parasite from infecting the water.

5. **Fasciola hepatica (Liver Fluke).**—This was formerly known as *Distomum hepaticum*. It specially affects the sheep causing a disease known as "liver rot", and consequently is of great economic value. It is 20 to 30 mm. long, 8 to 13 mm broâd with a narrow cone-shaped anterior projection bearing the oral sucker; the posterior is rounded. It is pale-grey in

colour with dark borders. The intestinal canal is branched, both branches being furnished with diverticula radiating onwards.

The fertilised egg when expelled from the bile duct into the sheep's intestine is passed out with the fæces and becomes a miracidium, which, if it encounters a fresh-water snail, enters its body where it is transformed into a tadpole-like cercaria. It passes out of the snail, sheds its tail and leaving the water moves up a grass blade where it encysts. When this grass is eaten by a sheep the young fluke is set free in its intestine. It then finds its way to the bile duct, makes fast to the duct wall and attains maturity.

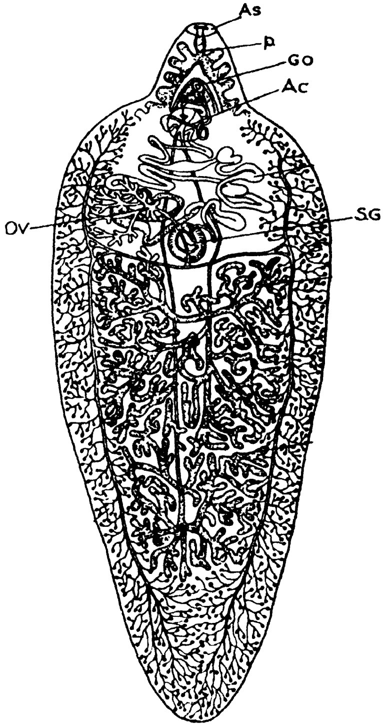

FIG. 128.—FASCIOLA HEPATICA
(Manson's Tropical Diseases)
(For lettering, *see* under figure 124)

6. Paragonimus ringeri and **P. westermanii (Lung Fluke).**—This fluke occurs in the East, chiefly Korea, Japan, Formosa, China and the Philippines and is found in the lungs of man, cat, dog, wolf, etc., forming tunnel or burrow of infiltrated lung tissue. The symptoms resemble those of tuberculosis with hæmoptysis. It is somewhat translucent, reddish-brown in colour and oval in shape, though looks almost round owing to thickness. It is 8-20 mm. long and 5-9 mm. broad, being blunt anteriorly. The oral sucker is terminal or sub-terminal, and the ventral sucker is placed anteriorly to the middle of the body. The cuticle is studded with wedge-shaped spines which differentiate it from the Westermanii in which they occur in clumps.

The miracidium after escaping from the eggs enters the fresh-water snail, *Melania*, which serves as the intermediate host, where it goes through the developmental changes with the formation of cercariæ, which escape into the water and bore their way into certain species of fresh-water crustacea where they encyst themselves in the liver, muscle or gills. Man is infected by eating raw fresh crustacea. In Korea and

Formosa uncooked crabs are not eaten, in these cases the cercaria probably enters the body through drinking water.

Prevention depends upon the use of pure water both for drinking and other purposes and by avoiding eating uncooked crabs, etc., which may harbour the young parasites. The sputum should be properly dealt with.

Cestodes

The members of this class which are indigenous to man are long, flat and tape-like worms inhabiting in their adult form the intestinal canal. They are usually segmented, white or yellow in colour, without mouth or alimentary canal, and lead a parasitic life by attaching themselves to the intestine by means of hooks and suckers. The head is known as "scolex," the whole body a "strobila," and the individual segments as "proglottides." The proglottides nearest the head are the smallest and youngest, while the terminal ones are the largest and most developed. They are commonly known as tape-worms. Of these *Tænia solium*, *T. saginata*,

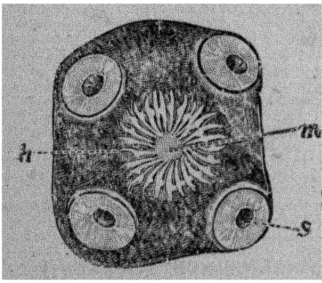

FIG. 129.
HEAD OF TÆNIA SOLIUM FRONT VIEW.
h, booklets; *s*, suckers; *m*, summit of rostellum.

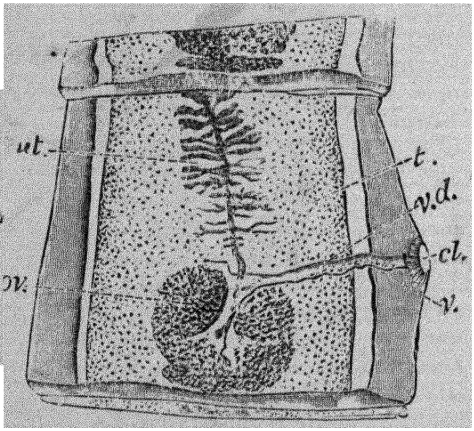

FIG. 130.
ONE OF THE MIDDLE SEGMENTS FROM A TÆNIA SAGINATA.
t, testes; *v.d.*, vasa deferentia; *ov*, ovary; ut., uterus; *v*. vagina, *cl.*, genital pore.

Dibothriocephelas latus and *Hymenolepsis nana* are found in the intestine, while *Echinococcus granulosus* is found in the cystic or intermediate stage in the liver or other parts. The worm consists of a minute head and neck with a longer or shorter row of attached segments. The head is about 1 mm. to 2 mm. broad, provided with suckers by which these worms fix themselves to the intestinal wall. Behind the head is a long narrow neck followed by rows of segments or proglottides of which the worm almost entirely consists. The

whole tape-worm is therefore often regarded not as a single animal, but as a polymorphic colony. These segments are small and imperfectly developed and less defined near the neck, but grow larger and more defined towards the end. The central and the more posterior ones are well marked with lines of demarcation, and present well developed generative organs Since they live directly on the nutriment derived from their hosts, these worms are devoid of any digestive organs, but possess a complete water-vascular system which take the form of longitudinal tubes running down each side.

The *life-history* of these worms is interesting. The mature proglottides are dislodged from the parent worm and

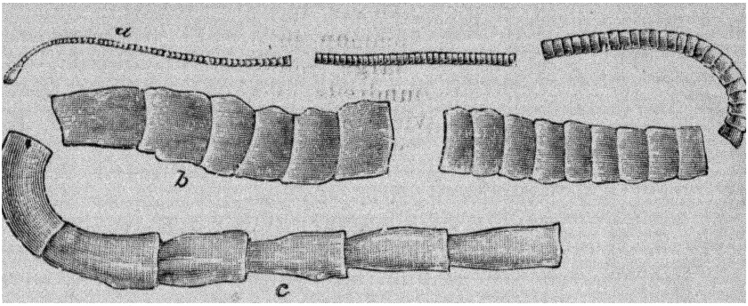

FIG. 131. PORTIONS OF A TÆNIA SAGINATA
a, head, neck and commencing segmentation; *b*, central and *c*, terminal proglottides.

pass out with the fæces, when the ova are set free, which retain their vitality for sometime. If at this stage these ova are eaten by some animal capable of acting as an "intermediate host" they continue their development until the shells are dissolved off in the alimentary canal and an embryo with six hooklets is set free. These hooklets enable the embryo to penetrate the wall of the alimentary tract and by way of the blood-stream or some other channel, reach some distant part. The hooklets eventually disappear and a cavity appears and a fully formed head is formed from the walls of this cavity which becomes enclosed in a fibrinous capsule supplied by the surrounding tissues. During the cystic or intermediate stage, the parasite becomes a cysticercus and is known as *Cysticercus cellulosæ* and may live for many months. If some tissue containing a living cysticercus is swallowed by an animal capable of acting as the "definitive host" the capsule is dissolved off by the gastric juice and the *scolex* or the head is set free. After attaching itself by its suckers and hooks to the intestinal mucous membrane it buds off successive proglottides from its distal extremity. It takes about two months between the swallowing of the cysticercus and the passage of the first proglottides from the rectum.

The *intermediate host* of *T. solium* is pig and the eggs enter the alimentary canal with contaminated water or soiled food. The onchosphere passes through the gut wall, enters the blood stream, settles down in the muscular tissue, loses its hooks and becomes *Cysticercus cellulosæ*. The eggs of *T. saginata* enter the gut of the ox when the onchospheres are set free in the small intestine. They bore through the gut wall and enter the muscle and become *Cysticercus* analogous to *T. solium*.

Hymenolepsis nana or Dwarf tape-worm.—It is a minute tape-worm parasitic in man, rat and mice, and is confined to Egypt, Soudan, Brazil, Japan and the warm parts of Southern Europe. It is also common in India, but because of its inconspicuousness it often escapes notice. It is also common in United States where it affects large number of children. It occurs in hundreds or thousands and gives rise to symptoms of pain, diarrhœa, epileptiform convulsions, headache, etc., due to absorption of toxins, produced by the parasites. It is $\frac{1}{4}$ to $\frac{1}{2}$ in. long, $\frac{1}{25}$ in. or less broad, very slender and when expelled resembles a little strand of mucus. The scolex is sub-globular and is provided with a well-developed rostellum to which are attached 20-30 hooklets. The neck is long, the proglottides are short anteriorly but increase in size towards the end, although they are always more broad than long. Each proglottides contain about 80-280 or more eggs which are oval or globular, double-shelled and are set free in the intestine. It undergoes complete development from the egg to adult stage without any intermediate host, the larval parasite enters the intestinal villus where it becomes a cysticercoid. Later it moves into the lumen of the intestine, attaches itself to the mucous lining and proceeds to develop. Diagnosis of its presence is done by examination of the stool for the presence of eggs.

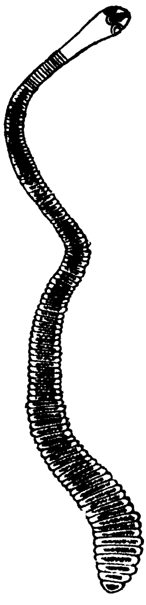

FIG. 132
HYMENOLEPSIS NANA

These worms are expelled by male fern, oil of chenopodium, or carbon tetrachloride.

NEMATODES

All round worms occurring as parasites in man belong to the Order *Nematoda*. They have very slender bodies without segments or appendages and are usually bisexual with a well developed mouth and alimentary tract at one end and an anus at the other. The males are usually smaller

than the females; some are quite harmless, while others are more dangerous. The following are some of the important worms parasitic in man:—

1. **Ascaris lumbricoides.**—In general form it resembles the common earthworm, being cylindrical and pointed at both ends, of pinkish-grey colour with a glistening surface when alive. They are the most frequent in occurrence of all the parasites and are especially so in children between the ages of three and five years. The adult female measures about 7 to 14 inches, and the male from 4 to 8 inches, being as thick as a goose quill. The cephalic extremity of both male and female has three oval papillæ furnished with fine teeth. The sexual organs occupy the posterior half of the body, the organs being at the junction of the middle and anterior third of the body. The female lays enormous numbers of eggs that have a thick shell, outside which there is often a clear, irregular, albuminous sheath. When swallowed these eggs find their way into the upper part of the small intestine where they develop into the adult form in the course of a month.

The eggs are present in great numbers in the fæces, and infection occurs without there being any intermediate host, by means of contaminated drinking water or food. Recently infection through the skin by the larvæ and by breathing in of embryonated eggs as dust has been proved.

Ascaris lumbricoides is found in all parts of the world. They occur in large numbers, in dozens and sometimes in hundreds in a single host. The effects are due to irritation giving rise to colicky pains, and in children often convulsions and other nervous symptoms possibly due to toxins which the worms naturally possess, or excrete as a product of their metabolism. The worms are migratory in their habits. They have been found in the bile-duct, pharynx, trachea and even lungs, giving rise to different symptoms. They may be matted together in the intestine and cause intestinal obstruction.

Prevention depends upon disposal of night-soil in such a manner as will make the transport of eggs and larvæ through water, food and air impossible.

2. **Enterobius (Oxyuris) vermicularis.**—These are commonly called "thread worms" and are found mainly in children. They inhabit the colon, especially the cæcum, where they may exist in enormous numbers. As the females become pregnant they pass into the rectum and lay an immense number of eggs. The female is $\frac{1}{3}$ to $\frac{1}{2}$ inch in length and the male half that size. They develop from ova in about three weeks; these ova do not develop unless passed through the stomach. They must, therefore, be passed per anus, and the host re-infected by the mouth before a new generation can develop. Water and food contaminated with the ova are

the common sources of infection. The female worms crawl out of the anus and deposit eggs on the skin near by which give rise to much local irritation and often lead to many different types of symptoms, *e.g.*, enuresis, cough, restlessness, convulsion, etc. They may enter the vagina in the female, and cause vulvo-vaginitis, pruritus and leucorrhœa. The itching leads to scratching and thus the eggs are often deposited under the finger nails. In careless and uncleanly persons the possibility of an auto-re-infection should be kept in view and steps taken to prevent the same. Children scratch and then suck their fingers, therefore, a child with thread worms should have its hands tied up in gloves during treatment so that the fingers will not reach the anus. The nails should be short and kept clean and dipped frequently in quassia infusion. The anus should be smeared with dilute ammoniated mercury ointment every night before going to bed. This not only allays the irritation and itching but kills the eggs. The children should be isolated until a cure is effected.

3. **Filaria**—The filariæ inhabit chiefly the blood vessels, lymphatics, connective tissues, and serous cavities of their host. Their mode of development is unknown, although it has been clearly established that they complete their life-cycle through parasitism in two sets of hosts. The host in which the filaria reaches maturity and gives birth to its offspring is known as definitive host, the other being known as intermediary or secondary host. In *Filaria* (*Wuchereria*) *bancrofti* we have an example of double parasitism, man and certain species of mosquito.

Filariæ are long slender thread-like worms with a curved or spiral tail. They are mostly parasitic in man. The *Filaria* (*Wuchereria*) *bancrofti* is found in the lymphatic glands and vessels, and the embryo is known as *microfilaria bancrofti*. The female has the appearance of a white thread about 3½ inches long. The male is very much smaller and less frequently found. In both sexes the posterior end is blunt and the head slightly bulbous with a central unprotected mouth. The generative organ is close to the head in females. The embryos (microfilariæ) found in the blood are about one-nineteenth of an inch long and in breadth equal to the diameter of a red blood cell. They are provided with a fine sheath which they do not completely fill and in which they can move backwards and forwards.

The nocturnal filaria is found only at night, or, if the host either by habit, necessity or choice, be a day-sleeper, during the day, thus showing that there is some condition of the body during quietude that is conducive to the appearance of the filaria in the blood. At midnight they appear in the greatest numbers, and Manson has estimated that there may be as many as 50,000,000 present in the blood of a single individual

at that time. They gradually diminish in number, and by six or seven in the morning entirely disappear.

The *microfilariæ bancrofti* are produced by the female in great numbers, and they are so small that they pass readily through the capillaries. During the night some of the parasites may be removed by various species of mosquitoes, viz. *Culex* and *Aedes* (*Stegomyia*).

It has been shown that the embryo once in the stomach of the mosquito sheds its envelop, pierces the wall of the stomach, and lodges in the thoracic viscera where it undergoes further development during two weeks, then finds its way into the proboscis to be discharged into the blood of the human host. Once introduced into the human body it finds its way into the lymphatics where it matures and brings forth young, and in due course a new generation of larval filariæ are poured into the lymph which may again infect the blood by passing through the lymph ducts into the thoracic duct and general circulation. It is evident, therefore, that like the malaria parasite the filaria is introduced into its human definitive host by mosquito bite.

Effects.—The most common effect observed is periodical attacks of lymphangitis with fever generally known as elephantoid fever. These attacks are accompanied by swelling of the affected limb, to be followed later by more or less permanent œdema of a greater or lesser degree. Several such attacks are followed by an overgrowth of the skin and subcutaneous tissue giving rise to *elephantiasis arabum*. Although the worm is primarily responsible for the damage to the lymphatic system, the pathological conditions in a large number of advanced cases of elephantiasis have been shown by Acton to be due to secondary bacterial infection. The toxin liberated by the adult female gives rise to allergic symptoms, such as periodic headache, migraine and rise of temperature. Once the case is developed few microfilariæ are found in the blood. The absence of embryos is due to the blocking of the channels through which they would reach the blood-stream. In some cases the lymphatics in the abdomen, scrotum, or the kidneys become varicose and filled with chyle giving rise to chylous ascites, lymph scrotum or chyluria.

Distribution.—Filaria bancrofti occurs in most of the tropical and sub-tropical regions and extends to North America, North Africa, China, Japan and Australia. It is specially prevalent in low lying coastal and riverine areas as seen in India where the main endemic centres occur in the deltas of the great rivers pouring into the Bay of Bengal.

A temperature ranging from 80° to 90° F. and a relative humidity of above 60 are necessary for the normal development of the microfilaria in the mosquito. Overcrowding is an important factor and infection is heaviest in towns and big densely populated villages, but low in the cities, where

good drainage and piped water supply afford small chances for mosquito breeding on a large scale. The microfilaria rate depends upon the density of the permanent population, the number of culex present in the house and the effective period for transmitting the infection coinciding with the culex population. In hyperendemic areas the first lesions are enlarged epitrochlear or inguinal glands followed by filarial abscesses and later by elephantoid lesions of the arms, legs or breasts. In endemic areas the blockage may occur higher up and hydroceles are common in young boys, and later on lymph varices of the cord. (Acton and Rao, *Indian Medical Gazette*, 1930.)

4. Dracunculus (Filaria) medinensis.—This is commonly known as *Guinea worm disease or Dracontiasis* and is found in the tropical and sub-tropical regions of Africa, Persia, Turkestan, Arabia, portions of India, West Indies, Fiji and parts of South America. Apart from the hill tracts, the incidence in India per 100,000 prisoners varies from 6 in Bengal to 3,964 in Mysore and west Madras.

The female is a thread-like worm generally 20 to 30 inches long. The body is more or less transparent, milky-white, smooth and without any markings. The tail ends in a hook-like process. Nearly the whole of the worm is occupied by the uterus stuffed with embryos. It normally lives in the subcutaneous tissue of man. When the head of the worm comes to the surface, or points, it produces itching and burning followed by a blister, which eventually bursts, and shows a small round hole in the centre. The transparent uterus in the presence of water discharges a milky-looking fluid containing myriads of embryos through this hole. These embryos swim actively in water and enter the body cavity of fresh water crustacean, *cyclops* or water-fleas, through the intestinal wall. Within this host the embryo passes through two moults and becomes mature in about five weeks. If the host dies a natural death the embryo dies with it. But if it dies when immersed in 0.2 p.c. hydrochloric acid, or in the gastric juice when swallowed with infected water, the worm leaves the host and becomes very active. It then enters the subcutaneous or intermuscular connective tissue, especially of the lower extremity as this part of the body comes more in conact with puddles of water where its intermediate host cyclops live. As a rule it causes no symptoms, but when it becomes mature, it perforates the skin and escapes from the body.

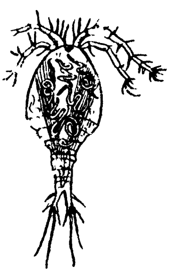

FIG. 133.
CYCLOPS.

Infection occurs from drinking water containing infected cyclops. Therefore certain factors contribute to the infection,

viz., a suitable temperature, presence of a suitable intermediate host, absence of filtered water supply and habits of the people regarding drinking water. One year generally elapses before the worm presents.

Prevention.—From the life-history of guinea-worm it is evident that the prevention from this disease depends upon protecting drinking water from being infected by guinea-worm patient. The cyclops are killed by heating the water or by adding a trace of potash. 10 grs. of lime (CaO) in a pint of water, with 9.5 grs. of alkalinity per gallon and 3.2 parts of free CO_2 per 100,000 parts kill cyclops in ten minutes. The minimum optimum dose was found by Pradhan to be one drachm of CaO per gallon, repeated every two weeks. The water is fit for drinking after ten days. Wells and tanks which are approached by steps are the greatest source of infection. In fact the infection is proportionate to the number of step-wells existing in the particular place. There should be arrangement for drawing water either by a pump or a bucket. The wells should be properly protected by a parapet. (A diagram of a Step Well is given under Village Sanitation).

5. **Loa loa (Filaria diurna).**—It is a thread-like worm of tropical West Africa and Uganda, and inhabits the connective tissues of man. It has a whitish, semitransparent, filiform and cylindrical body about one inch long, the female being double that size. The cuticle bears numerous translucent protuberances or tubercules. The embryo resembles that of *Filaria bancrofti*, but has a *diurnal periodicity* instead of nocturnal as in the case of microfilaria bancrofti. The development takes place in the same manner as *F. bancrofti*, the insect vector being a day-biting, blood sucking fly known as "mangrove fly", *Chrysops silacea* and *C. dimidiata*. After entering the human body it takes several years to reach sexual maturity. The microfilaria causes no symptoms, but the adults move about freely in the subcutaneous tissues and sometimes pass across the eyeball under the conjunctiva, the only symptom being a sensation of itchiness during their slow movements. The adult worm causes painless localised œdemas, known as *calabar swellings*.

6. **Onchocerca volvulus (Filaria volvulus).**—It is a common parasite infesting the subcutaneous tissues of man, specially around the iliac crest, the intercostal spaces and the axilla, where it causes cystic tumour of the size of a pigeon's egg. It is found in West Africa, Guatemala and Mexico. The head is rounded, and the body white and filiform, tapering at both ends. The cuticle is marked by transverse ridges. The males are 20 to 32 mm. long and 0.2 mm. broad; the females being much longer, about three times the size of the males. The males lie coiled round the females in the tumours, the posterior end being embedded in the tissues. The uteri of the females being packed with embryos, no embryos are

found in the peripheral blood slides. In later cases embryos appear in the lymphatics outside the swellings, specially in or about the groins, and that is how the intermediate host, *Simulium damnosum* (*see page 366*) when biting and sucking up lymph and blood gets infected, where the development of this filaria takes place.

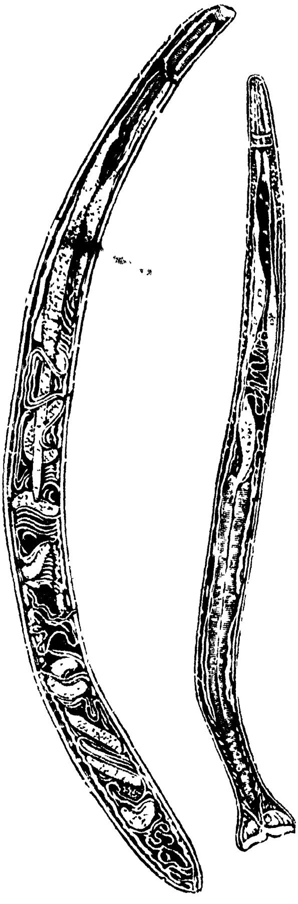

Fig. 134.
A. duodenale
Female
(After Looss)

Fig. 135.
A. duodenale
Male
(After Looss)

7. **Ancylostoma doudenale.**—Hook-worm is a common parasite of the intestine and causes a disease variously named. Thus in Columbia it is known as *Tun-Tun*; in Europe, Miner's Anæmia or Tunnel disease; in Egypt, Egyptian or Tropical Chlorosis. This disease was first described in 1648, but the cause was then unknown. The hook-worm was first discovered in 1782 and next noticed in 1789. In 1883 Dubini described it; since then the ancylostomum has been found so widely diffused that it may be said to occur in all tropical and sub-tropical regions of Asia and America. It is also present in south of Europe, and is very prevalent in India. Observations made in different parts of Bengal show an enormous prevalence of this affection. Roughly about 36 to 40 million people in Bengal are infected with larger or smaller numbers of the parasite. In Egypt it is found present nearly at every postmortem examination. About 70 p.c. of the workers of the coal mines of Bengal are infected without causing any apparent hook-worm disease. The hæmoglobin index amongst the infected is 12 to 15 p.c. lower than among the uninfected. The predominant species of hook-worm in the Asansol Mining Settlement is *N. americanus*, which constitute 70 p.c. of the total number of worms examined.

The International Board of Health (Rockefeller Foundation) is engaged in a widespread campaign against hook-worm infection not only in America, but also in many other parts of the world. In Ceylon, during 1923, about 500,000 out-patients were treated, whereas in Madras Presidency,

it is estimated that more than thirty-six millions are infected with hook-worm disease.

Source of Infection.—Infection generally takes place through patients suffering from the disease or through carriers. The number of eggs passed with the stool of a badly infected person has been estimated to be over 4,000,000, and as many as 4,000 worms have been recovered from a single patient, the usual number being from 50 to 125 per person.

Three distinct varieties of the worm are recognised. The *Ancylostoma duodenale* or the old form, *A. braziliense vel. ceylanicum*, and *Necator americanus*, the New World species. All types are common in India, Ceylon, Malay States and Siam.

A. duodenale is almost cylindrical, the males 8 to 11 mm. long and 0.4 to 0.5 mm. broad, and the females 10 to 13 mm. long, 0.6 mm. broad. Its body is thread-like with a conical-shaped head, and a large bell-shaped mouth surrounded by a horny capsule, with four vertically situated hook-like teeth and two smaller vertical teeth on the dorsal side, by which the worm fixes itself to the mucous membrane. Towards the tail end of the male worm there is an umbrella-like expansion or copulatory bursa. The eggs are found in muddy water, or in warm moist earth where they liberate the embryos. These develop into larvæ which soon enter the dormant state, remaining quiescent for an indefinite period until they are taken into the human stomach.

N. americanus is shorter and more slender than *A. duodenale*. The males measure 7 to 9 mm. in length and 0.3 mm. in breadth, and the females 9 to 11 mm. in length and 0.4 mm. in breadth. The vulva is placed slightly in front of the middle of the body. The adult worm lives in the small intestine and produces toxin.

A. braziliense is much smaller than *A. duodenale*, the males being 8.5 mm. long, and the females 10 mm.

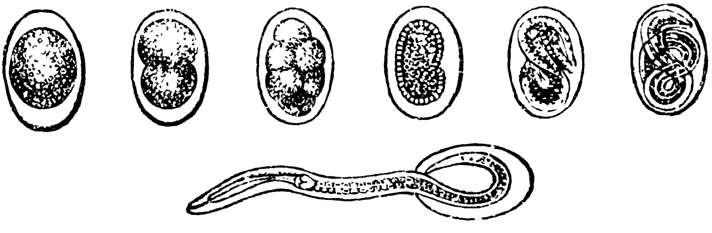

FIG. 136.—EGGS OF HOOK-WORM WITH EMBRYO ESCAPING FROM ITS EGGSHELL.

Man is probably the only host of this worm, although the same species is said to be parasitic in certain monkeys. The parasite inhabits the duodenum and upper parts of the small intestine.

Mode of Infection.—Hook-worm disease is pre-eminently

a rural disease, being limited to imported cases in large cities. Two modes of infection have been proved experimentally, *viz.* through the mouth directly, and through the mouth indirectly by way of the skin. Direct mouth infection may take place by taking embryos in drinking water, or soiled food, or from infected fingers. It is, however, of minor importance in the dissemination of the disease.

The real source of hook-worm infection is the faeces of infected persons and the only practical mode of infection is that described by Looss by the skin. The ova are passed with the stools of infected persons in the four-celled stage. The eggs are clear, thin-shelled and colourless. They are ovoid in shape, and under the microscope look faintly greyish with a greenish or bluish tint. Further development depends upon the presence of oxygen (air), a moderate degree of warmth and some moisture, when development of the embryo in the eggs proceeds very rapidly, and within about 24 hours the eggs assume the characteristic tadpole stage. The newly hatched embryos are about 0.25 mm. long with a blunt head. Their growth is also influenced by air, warmth and moisture, the food being supplied by the organic matter in the faeces. Within 48 hours after hatching they become double their size, shed their cuticle and enter the second or larval stage. Under optimum conditions these larvae become mature in 4 to 5 days, when they attain the infective stage and are ready for penetration of the final host. At this stage the larvae no longer feed, in fact they do not search for food, but live on the reserve food material stored up in the walls lining the digestive tract. Under favourable condition of moisture and warmth they remain on the surface of the soil or within the upper layer and climb upon the surface of any projecting objects, *e.g.*, dead leaves and sticks, soil particles, etc., but only as far as surface film of moisture extends.

It was formerly believed that once the larvae reached the mature infective stage they live for a long time, even years. This, however, is not the case. In Calcutta in summer Chandler found the length of life to be *less than two months*, the mortality being very great within the first three weeks. At this stage they possess a wonderful ability to penetrate the skin to which they can attach themselves even after a very brief contact. The skin of the foot in persons going about without any protection is commonly the site for the entrance, although ankles, hands and arms may also be attacked. Once having fixed on the skin the larvae leave behind the sheath and cause at the point of entrance *dermatitis*, which is variously known as "ground itch," "toe itch" or "ground sore." After reaching the subcutaneous tissue they enter the lymphatics and gain the blood stream. Through the blood they are carried to the heart, then on or

about the third day pass to the lungs. Breaking through the thin-walled alveoli they enter the bronchi, then *via* the trachea and œsophagus reach the mouth, and are either coughed out or swallowed. During this migration the third moult takes place and a terminal buccal capsule is formed. In the stomach they remain uninjured by the gastric juice and pass into the intestine on the seventh day when the fourth moult takes place and the terminal buccal capsule is changed for what is known as a provisional buccal capsule. On or about the 15th day, after entering the body, the provisional buccal capsule is cast and the larvæ develop into the adult form. The worm becomes sexually mature in three to four weeks, when copulation takes place and fertile eggs are laid.

Identification.—The distinguishing characters of the two common species are given in the following table, and the student should be able to differentiate them with a hand lens.

A. duodenale	*N. americanus*
Head relative to the thickness of the body is larger and slightly bent dorsally.	*Head* smaller relative to the thickness of the body, and bent conspicuously dorsally at an angle of 90 or more.
In males, *bursa* is short and broader than the adjacent part of the body.	*Bursa* longer than broad, only a little broader than the adjacent part of the body.
Lateral rays are all spread apart.	*Two lateral rays* are closely approximated and parallel.

Symptoms.—There is probably no disease in which the symptoms are so variable as in hook-worm disease. They are mainly due to loss of blood and the effects of a toxin which may have some destructive action on the blood. The most common symptoms are those of indigestion and dyspepsia. Lack of energy, apathy and anæmia are common during the early days of the attack, hence the disease is also known as "lazy disease." Except in severe and acute cases, or when the condition is of long standing the symptoms are indefinite. In well marked cases severe anæmia and dropsy are characteristic. Palpitation, shortness of breath and general weakness are often noticed. The taste may often become perverted and some patients show a craving for eating earth, mud and lime.

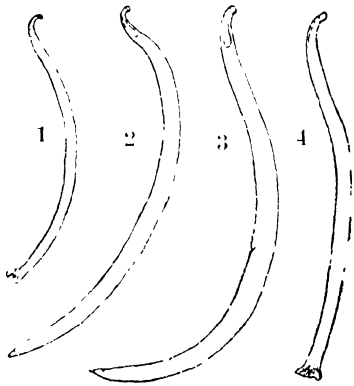

FIG. 137.—OUTLINE DRAWINGS showing relative length, thickness and shape of average of *N. americanus* and *A duodenale.* (1) *N americanus* male. (2) same female. (3) *A duodenale* female, (4) same male ×10. (After Chandler).

The exact number of worms necessary to produce any serious effects in man has been much discussed. While it is possible that some persons can harbour quite a large number, several thousands, without fatal results, others show a marked lowering of hæmoglobin with only a few worms. Smillie and Augustine believe that "the greater proportion of persons with hook-worm infestation of slight degree suffer no measurable harm, and should be considered, not cases of disease, but carriers". They hold that all infections with 101 worms and upwards should require treatment. It should be remembered that when a patient is otherwise debilitated, as often happens in India, an infection with 100 worms or less may cause serious symptoms and require treatment.

Incidence of Hookworm Infection.—The different factors which influence the spread of hookworm infestation are temperature, rainfall, humidity and the condition of the soil. The temperature is the prime factor in determining their distribution over the surface of the earth. The most favourable temperature for the development of the mature larval stage is above 70° F. provided the maximum does not greatly exceed 80° F. (Chandler). Throughout the tropics and subtropics in the wet summer season the daily range of temperature is usually within these limits, and therefore suitable for rapid development of the necators. Next to temperature, rainfall considerably influences the distribution of hookworm. The eggs and larvæ cannot withstand effect of dryness, and a dry soil acts as a powerful controlling factor in the dissemination of the worm. A close relationship exists between the annual rainfall and the amount of hookworm infestation. Chandler has shown that when the annual rainfall is below 40 inches, even in the presence of soil infection, there may be a high incidence of light infestation, but heavy or even moderate infestations are absent or rare. When, however, the amount of rain is such as will keep the superficial layers of soil continuously moist there is a high incidence of the disease which may reach 60 p.c. to 80 p.c. Other factors, besides rainfall, are drainage, type of soil, humidity and the number of rainy days over which the rainfall for the month is distributed. The influence of the soil on hookworm infestation depends upon its suitability or otherwise for the development and continued existence of infective larvæ. The moisture content of the soil is of great importance, and Augustine found that 3 p.c. of moisture was the minimum amount in which the larvæ could live in a sandy loam containing some humus and a little clay. Soils which appear moist are more favourable for the larvæ than the apparently dry or nearly dry soils, even if the latter have enough moisture to prevent complete drying of the larvæ. Acidity in soil does not influence the incidence of hookworm infection. In fact Chandler has shown that severe infections

occur in tea gardens where the soil is invariably acid, usually with a pH 5 and 5.5. Similarly when the soil is heavily impregnated with salt, even when defæcation is indiscriminate and ground saturated with strongly brackish water, there is no hookworm infection.

Prophylaxis.—Theoretically prevention of hook-worm disease should be an easy matter, since its cause is known and all the characteristics of the parasite are understood. But in practice it is one of the most difficult disease to handle owing to its extensive prevalence, enormous reproductive power of the worm, rapid development of the ova in the infective stage, and because the infection is the direct result ot careless and filthy habits. The problem of prophylaxis involves the following:—

1. Extermination of the mature worms in the bodies of human beings, thus stopping the danger of infection.
2. Preventing the growth and existence of the larvæ.
3. Preventing the infection by larvæ that have developed notwithstanding the above efforts.

1. *Extermination of the Mature Worms.*—The first step in the prevention of the disease is to stop it in those already affected. Accurate diagnosis, careful treatment on modern lines followed by examination of the fæces will to a great extent reduce the supply of ova and the possibility of fresh infection. But there will still remain another source of danger through "carriers" who present no special symptoms, or symptoms so mild as to pass unnoticed, but who harbour from a few to a couple of hundred worms, which lay eggs in large numbers all the time. These carriers should be isolated and properly treated. Periodical examination of all persons living in infected localities and under conditions favourable to the existence of larvæ is necessary. In mills, factories, plantations, etc., all workers should be similarly examined, and any one suffering from dyspepsia or anæmia more carefully examined, and if any ova of ancylostomes are found in the fæces they should be segregated and properly treated with thymol, beta-naphthol, oil of chenopodium or carbon tetrachloride.

2. *Prevention of Soil Infection.*—The next essential is the prevention of soil intection. Ancylostomiasis is preeminently a filth disease and the only means of infecting the soil is by evacuation of the bowels where the ova in the fæces may later develop. Any measure to be useful and effective must be directed towards the prevention of this source of infection. The practice of the people to pass stools in or about the dwelling, open land or on the banks of rivers and tanks should be rigidly interdicted—a most difficult task which the sanitarian will have to face. The larvæ are scattered by rains and all traces of the fæces are lost, but the porous moist earth becomes permeated with the larvæ

in the encysted and infectious stage. Sufferers and the public should be impressed with the fact that the fouling of the soil is the cause of the trouble, and the danger of soil pollution and the necessity of avoiding such practices should be forcibly brought home to them. For the prevention of soil pollution, installation of sanitary latrines is essential. The construction and use of such privies and the safe disposal of night-soil should be carefully explained and their advantages clearly shown. Particular attention should be paid to providing easily accessible privy accommodation, especially where a large number of men congregate and work, *e.g.*, in mills, factories, in mining districts and along the highways of traffic. Septic tank latrines, or in their absence bored-hole latrines may be constructed (*see* pages 280 and 241). These latrines must be easily accessible, so that neither indolence nor weakness will lead to the use of less secure areas. They must be inaccessible to animals and screened against flies and other insects from transporting material from them. While devising privies and sanitary accommodations, the habits and prejudices of the people they are intended to benefit must be taken into account.

The larvæ are killed in deep or running water, but can live for long periods in shallow water along the edges of streams—just the place used by people for washing and other purposes. Moist earth, especially if sandy, so as to retain moisture, or shaded by vegetation, offers ideal conditions for the life of larvæ and should be dealt with properly.

3. *Prevention of Infection.*—Considering the fact that infection and dissemination of the disease are mainly due to the ignorance and uncleanly habits of the people, it is essential that steps should be taken to educate the public. Law is not the instrument best fitted to compel a man to be clean and live up to the rules of hygiene. To be effective, the people must appreciate the philosophy and spirit that originate such laws and measures. They should not eat unwashed fruits or vegetables, and should not drink muddy water, or water from dirty receptacles. All water for drinking purposes should be purified. Every one living in hookworm areas should be taught the essential facts about the worm and its effects. Specimens, charts, diagrams, illustrations of patients before and after treatment with descriptions should be exhibited, popular lectures given and pamphlets printed in the vernacular of the place, freely distributed. Cultivators and others working in mills, factories, plantations, etc., where the disease prevails should be told of the danger of going about barefoot. In rural areas where people work on the fields the use of shoes by the cultivators is unknown, and during the rainy season when the fields and roads are sloppy or partly inundated, villagers hardly ever have recourse to the use of boots and shoes. Be that

as it may, the utility of using boots and shoes, and in their absence wooden sandals (*Kharrams*), as a means of reducing and preventing infection should be impressed on the people.

Examination of Fæces for Ova.—The actual presence of hookworm in a person suspected to be infected may be determined either by microscopic examination of the fæces for ova, or by vermicidal treatment and the recovery of worms expelled. The following methods are generally used :—

Smear Method.—This is also called *slide method.* A small piece of fæces is emulsified with water and a portion of it is placed along with a mixture of glycerin and saturated solution of sodium chloride equal parts on to a slide. A small area is first marked on the slide with a grease pencil. The eggs, owing to the difference in the specific gravity, float on the surface and are seen by a low-power objective

Centrifugal Method.—A mass of fæcal matter is first mixed with water which is then placed in a centrifugal tube and centrifuged. The supernatant fluid is then poured off. A saturated solution of NaCl, or a mixture of glycerin and saturated solution of NaCl equal parts is added and thoroughly mixed. Add enough liquid to fill the centrifugal tube. Centrifuge again. Remove ova with wisps of cotton and examine under a microscope.

Direct Centrifugal Floatation (Clayton Lane). This consists in first centrifuging a suspension of one gramme of fæces in water, then mixing the sediment with about 18 c.c. of saturated solution of salt and centrifuging again in a special tube with the surface of the fluid in contact with a cover glass. Remove the cover glass by a rapid upward pull in order to remove a large hanging drop. Examine the drop by resting the cover by the corners on small plasticine cones on a slide with drop side down. The essential special apparatus consists of special centrifuge buckets provided with horns to prevent the cover glass from slipping while centrifuging, special flat-bottomed tubes of appropriate size, and cover glass 0.5 mm thick.

Isolation of Larvæ from Soil.—The isolating apparatus consists of funnels 9 cm. in diameter, and a filter with sieve (1 mm. mesh). The sieves are lined with one or two thickness of fine muslin. The stems are fitted with India-rubber tubing fixed with a glass nozzle at the free end. The tubes are controlled by clamps. The soil samples or soil cultures are placed on the sieve, and water at a temperature ranging between 115° to 120 is poured into the funnels to a level which reaches into the soil but not above. The apparatus is left standing over night. The water is drawn off into the centrifugal tubes and centrifuged and the deposit examined for larvæ.

CHAPTER XIX

RESTRAINT OF INFECTION

HAVING read in the preceding chapters the nature of the different infective agents and the various means by which they are carried into the human system, one can now appreciate the importance of the measures calculated to prevent or restrain the spread of different infectious diseases. Modern research has thrown considerable light on what formerly was full of darkness, and although much remains to be done, yet whatever progress has been made has exposed many defects and brought many changes in the older methods of prevention. Thus, our knowledge with regard to the transmission of malaria and plague has directed our attention to protection against mosquitoes and destruction of rats. Similarly our knowledge regarding certain food stuffs acting as a source of danger has led to the introduction of inspection of animals before slaughtering, model dairies, cow-sheds, slaughter houses, etc.

In order to fight with the different infectious diseases effectively it is of primary importance to be acquainted with the habits of the different organisms, and as filth, foul air, bad water and unhealthy surroundings are essential for their existence, cleanliness is the weapon to be used against them.

Before discussing the special preventive measures for individual infectious diseases it is necessary that the student should understand the general principles of the following:—

1. *Notification.*—This requires every practitioner who diagnoses a case of infectious disease to notify to the Health Officer or Civil Surgeon of the district to enable him to take necessary precautions at once.
2. *Isolation* of the infected person.
3. In certain more dangerous diseases, like plague, small-pox, etc., *quarantine* may be imposed on persons who have been in contact with the patient.
4. Protective inoculation or production of *artificial immunity.*
5. *Disinfection.*

1. NOTIFICATION

By "notification" is meant the immediate intimation of the outbreak of every case of infectious disease to the Health Officer or sanitary authorities.

Notification of all infectious diseases to the sanitary authorities is only a means to an end, as it enables the Medical Officer of Health to take immediate measures for preventing

the further spread of the disease by isolation and disinfection, and other necessary action. According to Whitelegge the advantages of compulsory notification are:—

(*i*) Early and complete knowledge of all cases of notifiable disease, and thus of its whole prevalence and distribution in the district or town.

(*ii*) Power to exercise such supervision as may be necessary, over every case during its whole course, and to enforce due observance of the provision of the Public Health Act as regards isolation and disinfection. This is of great importance in the case of outbreaks of diphtheria, scarlet or typhoid fever in dairies, schools, etc.

(*iii*) Opportunity of removal to hospital of every suitable case; other preventive measures, as vaccination in cases of small-pox, can be offered.

(*iv*) Opportunity of investigating the sanitary condition of all households where cases of enteric fever, or diphtheria, or other notifiable disease may occur.

(*v*) Power to control the spread of infection through schools or other centres, by excluding members of infected households.

(*vi*) Means of detecting at once any suspicious grouping of cases around schools, and examining milk-supplies, water-supplies, and other common foci.

Immediate notification enables the authorities not only to isolate the sufferers and thus prevent them from acting as centres for disseminating the disease, but also to find out the real and original source of the same. With the poor, isolation in a hospital not only ensures proper treatment but also better comfort.

There is no Notifiable Diseases Act in India. Only a limited number of municipalities and the presidency towns enjoin medical practitioners to report infectious diseases, particularly cholera, small-pox, plague, typhoid fever, and diphtheria, occurring in private or public houses. But this has proved to be of little value. It is important also that the sanitary authorities should be in a position to adopt immediate steps for the isolation of patients at home, and for their removal with due care to special isolation hospitals.

Section 377 of the Bengal Municipal Act empowers the Commissioners to enforce all medical practitioners, or owners of houses to inform of the existence of a case of any dangerous disease in any building other than a public hospital. Section 378 empowers the Commissioners to remove to a hospital all patients suffering from a dangerous disease and who are also without proper accommodation or lodging or are lodged in such a manner that they cannot be effectually isolated so as to prevent infection or contagion. Section 379 empowers the Commissioners to cleanse or disinfect infected buildings, tanks, pools, etc., and under section 380 to destroy huts, sheds, etc., as the case may be.

2. Isolation

Isolation is separation of the sick, in case of any infectious disease, from the rest of the household, to render transmission of contagion from the sick to the healthy impossible. For persons in easy circumstances isolation can be satisfactorily carried out at home. But for the poor who live in insanitary *bustees* or quarters, with insufficient accommodation, and in schools, workshops, etc., the sick should always be removed to the nearest isolation hospital as soon as the infective nature of the disease is recognised.

Home or Private Isolation.—For the isolation of persons suffering from infectious diseases in their own houses the following points should be observed :—

(*a*) Whenever practicable the number of rooms should be two, on the top floor, or in a detached portion of the building.

(*b*) All furniture, clothes, etc., not required for the patient should be removed beforehand.

(*c*) The doors should either be kept closed, or a screen soaked in some disinfectant solution, like 1 in 20 carbolic acid, should be hung over them. This not only prevents germs from being carried by the wind, but also acts as a danger signal to the visitor.

(*d*) The windows should be kept open for free circulation of air.

(*e*) No one except those who are in actual charge of the patient should be allowed in the room. The nurses or attendants should take good care to wash their hands with some antiseptic lotion and disinfect their changed clothes. The dress of the attendants should be of some non-absorbent material which can readily be washed. Fresh dresses for nurses and attendants should be kept in the adjoining room.

(*f*) No clothing or utensil should be taken out of the sick room without previous disinfection.

(*g*) Excreta and food remains should be removed in vessels containing some strong antiseptic and then buried or burnt.

(*h*) Neither visitors nor any member of the house should enter the room, but if necessary should speak through the screen or window.

(*i*) When the danger of infection is over, the patient should be washed and bathed thoroughly with soap and water, and have a complete change of clothes before being allowed to mix with other people.

(*j*) Flies and mosquitoes must be absolutely excluded by screens ; those already present in the room should be destroyed.

It need hardly be said that the above precautions are very difficult to be carried out thoroughly in a private house, even if the patient and the family give the most willing assistance. It should be remembered that a very imperfect

and incomplete isolation is better than none, and may serve the useful purpose of checking the spread of an infectious disease. It is better, whenever possible, to remove the patient to the hospital, where he will be less dangerous to his own people and his neighbours; and where he will be assured of proper treatment and save the household of the risk and anxiety of further infection. But how far isolation is able to control mass infection and prevent epidemics is a controversial point. It is possible by a vigorous policy of isolation to restrain the sources of infection and prevent further spread of such diseases like smallpox, cholera and pneumonic plague, where the contagium usually passes from one to another directly without much aid of intermediaries. But in cases where the symptoms are masked in the early stages, as in measles, which is highly infective in the pre-eruptive stage, or where the transmission takes place through intermediaries or carriers, the isolation of known cases, when they are diagnosed, can have at most a partial effect on the general prevalence, since infection is continually coming along channels beyond its control.

Isolation Hospital.—In every town it is necessary that provision should be made for the accommodation and treatment of infectious cases. This is best carried out in an isolation hospital. The essential features of an isolation hospital are that the site should be dry, healthy and well drained, and although well away from congested quarters yet not far enough to cause inconvenience. Separate wards should be provided for admission and treatment of different infectious diseases. In India this is only done for cases of small-pox, cholera, and plague. A floor space of 144 sq. ft. should be allotted for each patient, with about 6000 cubic feet of fresh air per hour. One bed for every 1000 of the population is to be calculated upon. There should be a special observation ward where all suspected cases may be kept.

Proper arrangements should be made for the supply of pure water and removal of excreta and disinfection of soiled clothes, bedding, etc. In any case a steam disinfector is essential which should serve both for the hospital and also for the local health department. It is better to keep separate ambulances for the removal of the sick, but when ordinary carriages or *palanquins* are used care must be taken to disinfect them thoroughly.

Ambulances.—These may be either wheeled, or carried on the shoulders as *doolies* are. When wheeled, they had better be rubber-tyred; they may be drawn by horse, bullock or man; but the motor ambulances, as used in Calcutta, appear to be the best of all. They should be kept in all police stations and public places, and should be thoroughly disinfected after each use.

Segregation of the inmates of infected houses in special

camps is sometimes adopted as a precautionary measure for early detection of any case occurring amongst them. During the first outbreak of plague this method was adopted by the Government of India.

3. Quarantine

This is especially directed to the detention of healthy travellers after their departure from an infected place. Quarantine means detention of all persons exposed to infection for at least the longest incubation period of the disease. In theory quarantine appears to be a very effective means of stopping communicable diseases, but in actual practice this has invariably failed. The disadvantages are that it imposes restrictions on commerce and causes inconvenience to travellers.

Quarantine may be (*i*) *inward*, *i.e.*, when quarantine is imposed on a healthy town for its own protection, or (*ii*) *outward*, when it is imposed on an infected town or village for the protection of the surrounding country. If the patient is removed to a hospital, and disinfection of the infected house is properly carried out, it is not necessary to keep the family under quarantine. If the case is treated privately, the household must be placed under quarantine until the last case has ceased to be infectious and the final disinfection has been completed. Quarantine has been divided into :—

(*a*) *International Quarantine.*—This consists in compulsory isolation at the port of all persons coming from an infected place, or of persons who have been in contact with any case of infectious disease against which quarantine has been imposed.

The International Sanitary Convention of 1926, (*see* page 11), sought to devise uniform methods for the control of imported diseases without unnecessary interference with trade. The Convention encourages protective anti-cholera inoculation at ports of departure; and general six-monthly destruction of rats on ships. In the case of yellow fever, a ship arriving from an infected port may be claimed as healthy if, while there, she lay not less than 200 meters off shore or from hulks—this distance being beyond the flight of Aedes—or if she has been satisfactorily fumigated. Ships carrying typhus and smallpox are not to be classed as infected, but subject to isolation, supervision, vaccination or delousing, as the case may be, are to receive immediate pratique.

The Office International d'Hygiene Publique has for some time been engaged in the consideration of the advantages which the employment of wireless telegraphy presents for the transmission of sanitary information by ships prior to their arrival in port. As a result of the investigations a general report was prepared which was accepted by the Permanent

Committee and which aims at the recognition of a few standard messages, universally understood in the quarantine practice of every port, which would be sent by the ship to the nearest land receiving station, preferably not more than twelve or less than four hours before arrival at the port. The Port Sanitary Authority would eventually receive the messages, and, depending on their nature, would decide whether or not to permit the ship to enter the port with or without a medical examination, or to require it to anchor in the quarantine station of the port. This expedites the normal quarantine procedure and assists the Port Medical Officer by supplying him with advance information. A special code is used to save expense.

(*b*) *Scholastic Quarantine.*—Since children are more susceptible to infection, due measures specially to check the spread of the disease amongst them should be taken. Children from an infected house during the period of quarantine should not be permitted to attend school until the last case has ceased to be infectious. Closing of schools should be enforced unless there be a clear prospect of preventing the spread of the disease. (*See* Medical Inspection of Schools).

(*c*) *Domestic Quarantine.*—This often becomes necessary for members of an infected household. In the case of small-pox every member of such a house should be placed under a strict watch for a period of at least ten days after the last contact or until such persons are successfully vaccinated. Whenever possible quarantine should also be insisted upon with milk-men (*Goalas*), tailors, etc. All persons, particularly children should be strictly prohibited from entering into an infected house.

Objections to Quarantine.—The objections to quarantine are as follows:

1. The infective period in some diseases being much longer than any period of quarantine, the infected persons and the contacts may carry infection for a longer period than can well be covered by quarantine.

2. Quarantine very often interferes with food-supplies, and may thus cause privation and predisposition to disease; and by interfering with trade it alters prices and affords strong temptation for evasion.

3. The association of the healthy with the sick in a place (lazaretto) is not only undesirable, but tends to keep the disease alive.

4. The disease is very often concealed owing to fear of quarantine.

4. IMMUNITY

By *immunity* is meant non-susceptibility to a given disease or a given organism either under natural conditions or under conditions experimentally produced. By *tolerance*

is meant partial or limited form of immunity. Although the term is generally applied to a condition produced after repeated use of certain drugs like opium, it is now used increasingly, to denote the peculiar form of partial immunity that is developed in protozoal diseases like malaria. As a result of continued infection and reinfection with the malarial parasite a condition is established in which the host is able to live a more or less healthy life and to offer some resistance to reinfection while still harbouring the parasite in small numbers. This type of infection-immunity is spoken of as '*tolerance*' or '*premunition*'.

The existence of immunity to infection was recognised ages ago. In ancient India and China the people had made the simple observation that a person who had recovered from an infectious disease, such as smallpox, was thereafter resistant to reinfection by the virus of the same disease. Thucydides in Greece had also made a somewhat similar observation with regard to plague. Although these people knew of the existence of immunity, it was not until the latter part of the eighteenth century that the true foundation for the study of immunity was laid. Jenner through his monumental work on smallpox vaccination gave a great impetus to the subject. Further progress was achieved through the researches of Pasteur in hydrophobia and anthrax; Koch in tuberculosis; Loeffler, Behring, Roux and Kitasato in diphtheria, tetanus, and pneumonia; Haffkine in plague and cholera; and Wright in enteric. Although our knowledge of immunity mechanism is incomplete even now, many valuable contributions have been made to the subject within the last two decades.

For purposes of description immunity may be classified as follows;—

A. Natural or Inherited
- species
- racial
- individual

B. Acquired
- active
  - natural—through attack of disease.
  - artificial—induced through inoculation of
    - (*a*) living virulent virus.
    - (*b*) living attenuated virus.
    - (*c*) dead virus.
    - (*d*) toxin of virus.
- passive
  - natural or congenital—through transference of antibodies from mother to child
  - induced—through inoculation of
    - (*a*) anti-toxin serum.
    - (*b*) anti-bacterial serum.
    - (*c*) convalescent serum.

A. Natural Immunity.—This form of immunity is possessed by man and animal either from birth or acquired during growth by virtue of its species, racial or individual peculiarities. As an instance of *species immunity* may be mentioned the immunity of hens against tetanus, and of dogs, rats and mice against tuberculosis. The immunity of certain races to certain diseases as for example, the immunity of the negro to yellow fever is considered by some as *racial immunity*. Again some families are more resistant to certain diseases than others. Certain individuals also show varying degrees of immunity to some of the infectious diseases. In times of epidemics all persons exposed to infection do not contract the disease and even among those who develop it there are some who suffer more severely than others. All this is due to *individual immunity*. Natural immunity is neither absolute nor permanent. Through the administration of large doses of infective material it is possible to break down this immunity. The immunity of the hen to tetanus for example may be overcome by giving massive doses of tetanus toxin. In the same way it is also possible to enhance natural immunity by artificial means.

B. **Acquired Immunity.**—Immunity may be acquired in two ways—*actively*, or *passively*. It is called (*i*) *active* when the individual's own tissues play an active part in the process of acquiring the resistance, and (*ii*) *passive* when the resistance is acquired through introduction from without, of ready-made protective substances or antibodies from other animals of the same or another species.

I. **Active Acquired Immunity.**—This again may arise (*a*) *naturally*, or (*b*) may be *artificially* induced.

(*a*) *Natural Active Acquired Immunity.*—It is well-known that an attack of an infectious disease confers upon a person a certain amount of immunity from a second attack. The immunity that is so developed is known as *natural active acquired immunity*. While in smallpox, measles, chickenpox, plague and typhoid fever a high degree of immunity follows an attack of the disease; in influenza, pneumonia and gonorrhœa little or no immunity is conferred by an attack.

(*b*) *Artificial Active Acquired Immunity*:—When active immunity results from inoculation of material containing antigenic substances derived from bacteria or viruses, it is known as *artificial active immunity*. The term *vaccination* is applied to all methods of artificial active immunisation and the material used for vaccination is known as *vaccine*. A vaccine may consist of (*i*) living virulent virus, (*ii*) living attenuated virus, (*iii*) dead virus, (*iv*) split products from viruses, or (*v*) toxins. Various terms are also used to denote the method of manufacture of vaccines. Thus we have: *live vaccine*, in which the organism is alive and not dead; *sensitisen vaccine*, which is made by mixing the organisms with

specific immune serum; *autogenous vaccine*, which is made from the organism that is causing the infection in the patient; *stock vaccine*, which is made from organisms obtained from similar condition in other patients; *polyvalent vaccine*, which is made from several strains of the same organism isolated from different cases; *mixed vaccine*, which is made from two or more different organisms; *detoxicated vaccine*, which is made after removal of endotoxin of organisms; *lipo vaccine*, which is made by suspending organisms in oil instead of saline; *phylacogen*, which is made from solutions of bacterial cell bodies so as to be readily assimilable. Vaccines are generally given by injection in one or more doses at suitable intervals. Immunity is developed some days or weeks after the last injection, and is highly specific being effective only against the organism used for the preparation of the vaccine. The degree and duration of immunity vary considerably in different cases. After small-pox vaccination it is high and lasts a considerable time (several years); after vaccination for diphtheria, scarlet fever, typhoid, cholera and plague it is moderate and lasts for several months; and after vaccination for influenza, and pneumonia it is slight and lasts a very short time only. Natural active immunity confers better and more lasting protection to an individual than artificial active immunity. The latter is of very great value in the prevention of disease and of limited value in treatment.

II. **Passive Acquired Immunity.**—If an animal is immunised by giving a series of injections of a vaccine in gradually increasing doses and at suitable intervals, its serum is found to contain protective substances or antibodies which when injected into a susceptible animal confers immunity upon it, provided the serum is given either at the time of, or a short time after, the occurrence of infection. The immunity that is thus conferred through the injection of serum containing specific antibodies from another animal is known as *passive immunity*. This immunity is of short duration and is of particular value in treatment—chiefly for tiding over a crisis when antibodies are lacking in the blood of the patient. In diseases like diphtheria, tetanus, measles and poliomyelitis, passive immunisation has not only been used for curative purposes but also in prophylaxis.

Anti-sera are of three different types. Different terms have been used to denote the nature of these anti-sera. When bacterial cell body itself is used in the manufacture of an anti-serum the antibodies elaborated are found to have the power to agglutinate, opsonise, kill, or lyse the bacterial cell. The anti-serum in this case is known as *antibacterial serum*. Examples of such serum are anti-streptococcal, anti-meningococcal and anti-plague serum. On the other hand if the filtered toxin of a bacterium is used for the manufacture

of anti-serum then the protective substances present in it have the power to neutralise the toxins of the organism only and in this case the serum is known as *antitoxic serum.* Examples of such serum are anti-diphtheritic and anti-tetanic serum. In virus diseases like measles and poliomyelitis the serum of recovered cases contain specific antibodies for the virus. Such sera have been used for passive immunisation, and are known as *convalescent sera.*

Two terms commonly used in connection with immunity, in recent times, need a word of explanation. They are *herd immunity* and *local immunity.*

Herd Immunity.—By *herd immunity* is meant the immunity of a group of people or a community taken as a whole. In the study of epidemic prevalence of infectious diseases, it is found that a consideration of *herd immunity* is of greater importance than that of *individual immunity.* It is well-known that epidemics disappear from a community long before 100 per cent of the individuals composing the herd become immune. In a community of 100 persons complete immunity will be established even when, say, only 70 persons in it are actually immune. The other 30 persons although susceptible enjoy freedom from infection by virtue of their belonging to the herd. Thus herd or mass immunity differs from individual immunity. Furthermore a herd in addition to becoming immune in a manner similar to an individual can also become immune through a process of natural selection, *i.e.*, through the weeding out of the susceptibles in successive generations by disease and death. Similarly examples of low resistance of certain populations to infections with which they have not come in contact previously for many generations are numerous in epidemiology. (Tuberculosis among the aboriginal African tribes).

Local Immunity.—This term has recently been employed by Besredka to denote the resistance offered by tissue cells to infecting agents. In opposition to the popular view he believes that the cells of the tissue attacked are the cells primarily concerned in protection and not antibodies or phagocytes. In typhoid and dysentery the causative organisms attack the intestines and in anthrax the skin. If in these diseases the tissues attacked are rendered previously insusceptible then Besredka believes that the animal would behave as if completely immune. This immunity which is dependent upon the development of nonsusceptibility of tissues to the toxic action of organisms is known as *local immunity.* In connection with *local immunity* the term *antivirus* is often used. It is the name given to the material used for inducing local immunity. It is either a killed culture of the organism or a filtrate from such culture. Experimentally Besredka has shown that the application of staphylococcus or streptococcus *antivirus* to the shaved skin of rabbits confers

subsequent immunity to infection with these organisms. Some therefore believe that *antivirus* has valuable curative and protective properties. Dressings soaked in *antivirus* have been used in the treatment of staphylococcal and streptococcal infections.

Bacteriophage

The subject of *bacteriophage* is considered after immunity because, according to one view *phage* consititutes one of the defences against the ravages of pathogenic bacteria and is an essential factor both in cure of disease in the individual and in the decline and disappearance of epidemics from communities. The more widely *phage* is distributed in a community and its environment, the less is that community likely to suffer from epidemics. As this view of the importance of *phage* is not accepted by all, the public health authorities of this country are at present engaged in investigating the question further and therefore a consideration of the subject here will be found both necessary and helpful.

In 1917 d'Herelle found that the filtrates obtained from the liquid fæces of bacillary dysentery cases, when added in small quantities to young cultures of *bacillus dysenteriæ* (Shiga), produced lysis of the bacteria after a period of incubation. Filtrates of these lysed cultures also showed similar lytic properties. This property was not only transmissible in series indefinitely from culture to culture but was also capable of growing in strength in each culture. From this d'Herelle suggested that the lytic agent was an ultra-microscopic virus and named it *bacteriophage*. Although the majority of subsequent workers are inclined to accept this view of d'Herelle yet there are some who believe that the lytic agent is a non-living substance of the nature of enzyme. This difference of opinion has stimulated greatly the study of *phage* and has led to very fruitful results. As a consequence, we are in possession of a good deal of facts regarding the properties of *phage* and its mode of action on bacterial organisms. Briefly, the most important properties of *phage* are its filtrability, its ability to multiply in the presence of young growing bacteria, its resistance to heat and alcohol, its susceptibility to acids and alkalies, and its ability to act as an antigen. And as regards its action on organisms we know that in the presence of specific *phage* bacteria may get lysed, alter in virulence, change their cultural characteristics and become modified as regards antigenic properties. The organisms most susceptible to such action by *phage* are the members of the colon-typhoid group and the vibrios.

The value of phage so far as the clinician and the public health worker are concerned is dependent upon its therapeutic value. In diseases like cholera and dysentery the use of a specific highly potent *phage* is said to be of some

value both in treatment and prevention. In India at the present time *phage* is being manufactured in several important laboratories on a large scale and is being tried extensively in the field for the cure and control of cholera. Experiments so far carried out independently in the provinces of Madras, Assam and United Provinces, have not yielded any conclusive results. All that can be said at present regarding the value of *phage* in cholera is (i) that in prophylaxis there is some evidence that administration of *phage* helps to reduce mortality though not morbidity, and (ii) that in treatment giving of *phage* is better than giving no treatment, but it is not distinctly better than giving other recognised forms of treatment. (For further information on *phage*, *vide* section on cholera).

5. DISINFECTION

Disinfection means destruction of the specific virus of infectious diseases. *Disinfectants* or *germicides* are substances which destroy pathogenic microbes, *i.e.*, those which cause communicable diseases, and so prevent them from spreading. *Deodorants* or *deodorisers* oxidise products of decomposition and so adsorb or destroy offensive smells.

Practical disinfection is utilised for :—

1. Destruction of microbes deposited on walls, crevices, floors, etc., of rooms, furniture, and other articles.
2. Destruction of disease germs in bedding, clothing, etc.

It is not enough to know that a substance is a disinfectant, but the quantity to use and the degree of concentration required are important factors. It is also necessary that the disinfectant should come in direct contact with the micro-organisms. Some deodorants destroy offensive odours by simply substituting an agreeable or a strong smell without destroying the organisms giving rise to putrefactive odours.

Disinfectants may be classified as follows :—

I. Natural.
II. Physical.
III. Chemical.

I. Natural Disinfectants

Fresh air and sunlight are the natural disinfectants and kill most germs. By the process of desiccation all micro-organisms are sooner or later attenuated in their disease-producing activities. Typhoid, tubercle, and diphtheria bacilli resist drying for a long time, gradually losing their vitality. In fact it has been proved that direct sunlight will kill typhoid bacilli within one-half to two hours, and diffused daylight in about five hours. According to Koch, tubercle bacilli are killed by the sunlight in from a few minutes to several hours, according to the thickness of the mass exposed.

Drying on the other hand inhibits multiplication of bacilli, and putting in the sun and air of bedding, clothes, and other articles often secures the desired degree of dryness, while the oxygen of the air exercises a toxic influence on the organisms that may have been harboured in these articles.

Sunlight is a strong germicide and aids disinfection to a great extent. Although a large number of micro-organisms, *e.g.*, of diphtheria, plague, etc., are destroyed by the rays of the sun, yet as a disinfectant sunlight cannot absolutely be relied upon. The different rays have quite different effects on the micro-organisms. The red and yellow rays possess no disinfecting power. The blue-violet or the ultra-violet rays and the heat rays are powerful disinfectants. The tropical sunshine is rich in both the above rays, and natural disinfection of water in tanks, etc., is due to the presence of these rays. Diffused light, though less powerful, will also retard bacterial growth Ultra-violet rays produced by an electric discharge through mercury vapour contained in a quartz lamp in vacuo, have a powerful germicidal effect, and are used to purify drinking water.

II. Physical Disinfectants

Physical disinfectants include heat in its various forms and may be applied as :—

A. Dry heat	B. Moist heat
1. Burning by fire	1. Boiling
2. Hot dry air	2. Steam

A. Dry Heat

1. *Burning.*—This is the best means of disinfection, and should always be employed for articles of small value, *e.g.*, rags in which discharges have been received, pillows, old mattresses, etc. The destruction of all these articles is usually carried out in a small destructor furnace which should also form a part of the disinfection station. If carried out in the open air small unburnt particles carrying infection may be scattered by the wind. Cholera and enteric excreta should be burnt by mixing them with saw-dust and kerosene oil to ensure their thorough and complete destruction.

Cheap dwellings, like huts, that can readily be reconstructed, had better be disinfected by burning, especially where diseases like plague have occurred. Sputum and other discharges when small are best destroyed by fire.

2. *Hot Dry Air.*—Formerly this was the principal method for disinfecting clothing, bedding, etc. But to ensure the destruction of bacteria and spores the temperature must be high and the heating prolonged. It has little power of penetration, and requires many hours for the centre of a mass of bedding to attain the required temperature for sterilisation, whilé some articles and fabrics are distinctly injured by the prolonged heating. For these reasons disinfection by dry

heat has been replaced by steam disinfection except to kill lice and other insects.

B. **Moist Heat**

1. *Boiling.*—This is one of the most efficient methods of disinfection. Infected articles can be disinfected within about 20 minutes by boiling. It takes about 10 minutes to kill typhoid bacilli at a temperature of 140°F. and 5 minutes for comma bacilli at 126°F. In fact all bacteria and even spores are killed at the temperature of boiling water. Spores of many pathogenic micro-organisms are killed by boiling for 5 minutes. On the other hand *Bacillus anthracis*, *B. tuberculosis* and *Streptococci* of puerperal fever require boiling for a longer time for their destruction. Beds, linen, etc., are best disinfected by boiling. Bed pans, urinals, cooking utensils, and other vessels used for the sick are also disinfected by this method. Clothes stained with blood and fæces should first be boiled or soaked in some disinfectant and then cleaned with soap and water. Floors, walls, tables, etc., may with advantage be disinfected by mechanical washing with boiling water. An addition of 2 per cent. of washing soda accelerates the germicidal power of boiling water. The disadvantages of this method are that it is slow, and not suited for woollen materials which shrink. It fixes albuminous stains, but if cold water is brought to boil it will not do so.

2. *Steam.*—This is the most efficient and practical way of applying moist heat for purposes of disinfection. Its value depends upon the physical property which steam possesses of parting with its *latent heat* in passing from the gaseous to the liquid state. Steam enables a higher temperature to be reached without any damage to the articles, and has a penetrating power infinitely more rapid than dry heat.

When steam, whether *current steam* at normal pressure or high temperature steam under pressure, comes in contact with articles cooler than itself, it immediately condenses and in so doing parts with its *latent heat*. Successive volumes of steam condensing in this manner very rapidly penetrate and raise the temperature of the articles in a disinfecting apparatus. It is this rapidity of action that gives steam its great value as a means of sterilising infected articles. Steam will destroy all micro-organisms and spores at a temperature of 212°F. in five minutes, whereas hot dry air would require a temperature of 250°F. for four hours. Steam used may be either *Saturated or Superheated*. When steam is generated by boiling water in a closed vessel, *e.g.*, in a steam boiler, it accumulates under pressure, and the longer the water is boiled the greater will be the pressure. The steam so generated is called *saturated steam*. Saturated steam readily conveys heat, and condenses to $\frac{1}{1600}$th part of its original volume as soon as it comes in contact with articles slightly cooler than itself, and by giving off its latent heat becomes smaller

in volume ; consequently more steam is drawn into the partial vacuum thus produced, and the process is repeated until every portion of the articles is raised to the same temperature as the steam itself. Therefore disinfection by saturated steam should always be preferred on account of its more rapid and thorough penetration. The temperature of saturated steam may vary considerably and depends upon the pressure at which it is generated. By increasing the pressure, steam at temperatures above 212°F. can be obtained, but it always remains saturated as long as the pressure remains constant. If all the water in the vessel is converted into steam and the process of heating continued and pressure relaxed, the imprisoned steam is raised high in temperature, *i.e.*, it becomes superheated. This *superheated steam* has properties similar to those of a dry gas, which has lost its physical character as vapour and cannot condense, and therefore it is inferior to saturated steam as a disinfectant.

Current or low pressure steam disinfectors although cheap at the outset are expensive in the long run because they consume more fuel. They also have the great disadvantage of delivering articles wet and are not suitable for rapid work in a big disinfecting station. Moreover the higher the pressure of the steam the more rapid is the penetration, and the less time required for disinfection. A temperature of 234° F. to 248° F. for twenty minutes is trustworthy in all cases. This is obtained by pressure of 15 to 20 lbs. per square inch.

It should be remembered that some fabrics are damaged by heat ; woollen materials shrink when moist heat is applied and acquire a distinct yellow tinge when exposed to steam at 260° F. for about thirty minutes. Feathers become yellow or brittle after an exposure of four hours to moist heat at 260° F. ; silk, cotton, and linen will stand a moist heat of 260° F. for half an hour and dry heat of 230° F. for four hours with little damage. The majority of substances will stand a temperature of 230°F. without much injury.

Steam Disinfecting Station.—A disinfecting station should consist of two rooms—one for the infected and the other for the disinfected articles. Each room should have a separate entrance and should be completely separated from the other by a wall, into which the stove is built, which communicates with both the rooms. The infected articles are placed on trays which can be easily introduced or removed from the disinfector. The time required for disinfection depends on the bulk, the nature of the articles and the pressure of the steam employed. There should be arrangements for ascertaining the temperature of the interior of the stove at any time.

Of the high-pressure disinfectors the better known ones are the *Washington-Lyon* (*Manlove and Alliott*), the *Equifex (Geneste-Herscher)*, and that of *Goddard, Massey and Warner.*

The *Reck's apparatus* and *Thresh's Current Steam Disinfector* are examples of low-pressure ones.

1. *A Modern Disinfector* is an elongated cylindrical boiler, oval in section, with a steam-proof door at both ends. It consists of an outer and an inner chamber, the outer one enveloping the inner chamber and is called the "jacket." This jacket is first filled with steam at about 20 lbs. to the inch pressure so as to thoroughly heat the walls of the disinfecting chamber. This prevents condensation on the walls of the steam subsequently admitted to the main chamber. The inner chamber contains a cradle or truck made of galvanised iron wire, which runs on rails. The articles for disinfection are placed in the chamber and the doors locked home. Steam at 15 lb. pressure is then allowed to fill the chamber and at the same time a vacuum exhaust is set going to extract the air.

By alternating the admission of steam and extraction of air very rapid action ensues; successive volumes of high temperature steam condense on the colder mattresses, blankets, etc., parting with their latent heat until the whole mass is raised to a uniform temperature. The exhaust is closed and steam is allowed to act at full pressure for about twelve minutes. The steam valve is now closed, an air inlet is opened and the vacuum exhaust set to work drawing in a current of air and exhausting the steam. The very hot jacket aids this drying process and in a few minutes the door at the clean end of the disinfector is opened and the clothing and bedding removed not only sterilised but quite dry.

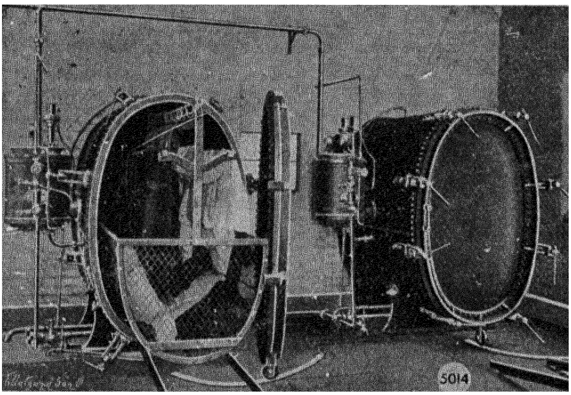

FIG. 138. STEAM DISINFECTOR. (Manlove and Alliott).

This is a great saving of time which is all important when dealing with large bodies of men whose kits have to be disinfected, such as pilgrims entering on board ship

2. *Thresh's Current Steam Disinfector* consists of a chamber surrounded by a jacket. In this apparatus steam is generated from a saline solution, usually calcium chloride, which raises the boiling point of water above 212°F. without any extra pressure. The machine is so contrived that the original amount of calcium chloride may be used over and over again, the boiler being fed with water by an automatic feed cistern. Although it is a low pressure apparatus, the steam is hot, as it is given off from water over 212°F. It consists of two chambers; the outer one contains the boiling saline solution, while in the inner chamber the articles to be disinfected are placed. When the temperature of the inner compartment reaches 225°F. steam is made to enter which disinfects the articles.

3. *Lelean's "Sack" Disinfector* is a light and simple apparatus for disinfecting clothing, bedding, etc., by means of current steam. It was originally used during the war, but has been modified to suit the requirements of municipalities.

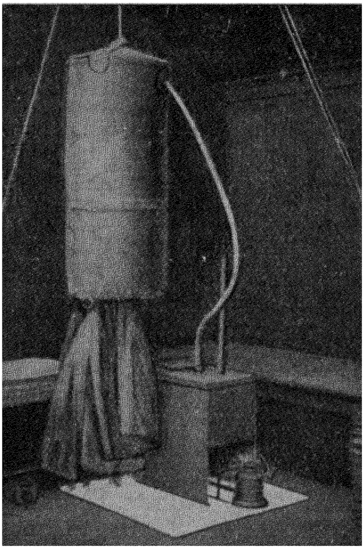

Fig. 139.—Lelean's Sack Disinfector

It consists of a seven gallon boiler, a hose pipe, a sack four feet long and two feet in diameter (fitted with a suspensory disc), a special pressure oil stove, and an insulating furnace.

The sack, made of steam-proof canvas, is suspended like a bell, the lower end remaining open. The soiled articles hang from a frame with hooks fitted at the top. Steam admitted through the hose at the top fills the sack, and can be allowed to act as long as is considered necessary. The hanging frame is fitted with a rope and pulley and can be lowered out of the open mouth of the sack and fresh articles hooked on and hauled up to the top.

It has been shown that within two minutes of steam emerging from the inverted sack, all non-sporing organisms placed in the middle of the bundle just inside the sack mouth, were killed; and the spores of anthrax similarly placed were found to be killed in five and a half minutes.

4. *Serbian Barrel.*—This is one of the best improvised methods of steam disinfection much used during the last

war. It was first introduced in Serbia and Bulgaria during the typhus campaign for delousing clothes, etc. It consists of a barrel with a perforated bottom which rests on a sand bag collar to prevent the escape of steam which enters the barrel through the perforated holes from a metal tank containing water upon which it rests. The top of the barrel is covered with a removable lid with hooks to hang soiled articles, clothes, etc. The barrel with the boiler is placed on a brick-work frame forming the furnace.

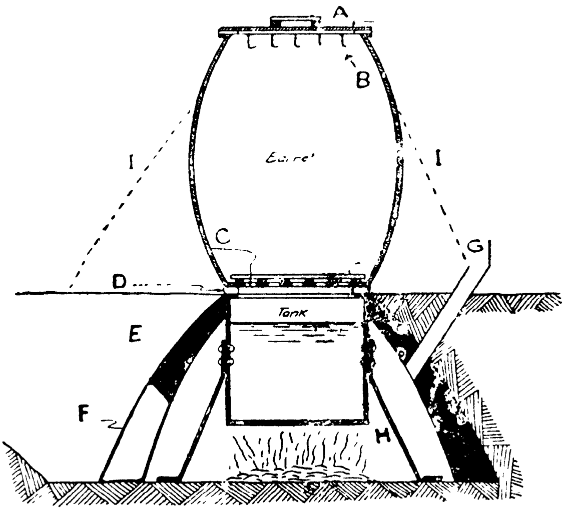

FIG. 140.—THE SERBIAN BARREL.
A, Cover; B, Hooks for hanging clothing; C, Perforated wooden frame; D, Sand bag collar; E, Stoking pit; F, Opening for stoking; G, Chimney; H, Furnace; I, Clay casting.

III. CHEMICAL DISINFECTANTS

The exact manner in which the chemical disinfectants act is not fully understood. The degree of ionisation of a solution may possibly have an important bearing on its disinfecting efficiency. Briefly, disinfectants act (*a*) by oxidising the protoplasm of the bacteria; *e.g.*, the halogen compounds, bleaching powder and potassium permanganate liberate nascent oxygen; (*b*) by coagulating the protoplasm of the bacteria, *e.g.* the phenols and their derivatives; (*c*) by ionic coagulation, *e.g.*, the metallic salts; (*d*) by absorption of water (desiccation); and (*e*) by emulsoid action and adsorption. Admitting the value of the disinfectants, there are certain limitations. For instance, the presence of electrolytes may lower their value; oxidising agents give up oxygen so rapidly that they soon become inert; and lastly the metallic disinfectants do not penetrate readily. The

temperature has also some significance. For instance, the germicidal value of phenol increases 7 to 8 times with every 10°C. rise of the temperature. Warm solutions are therefore more useful and should be used.

The choice of a germicide depends on the nature of the substance to be disinfected and upon the resistance of the virus. Thus, perchloride of mercury 1 in 1000 solution, or carbolic acid 2.5 p.c. solution, will not kill the spores of tetanus. Whereas a weak solution of hypochlorite will sterilise water, a strong solution is needed to disinfect fabrics. The choice of the disinfectant, its strength, the time of application, the temperature of the solution and the method of application all require careful consideration for each particular class of infection.

The following are the requirements of an efficient disinfectant :—

1. It must be a powerful germicide and rapid in action and should possess great power of penetration.

2. It should have a definite efficiency for particular organisms under given conditions, and should be permanently homogeneous.

3. Its chemical properties should be such as will render it fit for ordinary use and not become inert by fæcal or any polluting material, *i.e.*, it should be stable in the presence of organic matter.

4. It should not have any injurious effects on human tissues and materials submitted for disinfection.

5. It should be soluble in water or form a uniform emulsion in all proportions.

6. It should be fairly cheap, and should not act on metals, bleach pigment or spoil fabrics, and be neither toxic nor caustic.

7. It should have a high solvent power for grease.

Such an ideal disinfectant is not known ; therefore, considerable discretion is necessary in the use of the known ones.

Standardisation of Disinfectants.—In order that the different disinfectants may be used with some amount of precision it is essential to have some idea of the relative potency of these substances. Therefore a standard method of testing the various disinfectants under precisely similar conditions is of considerable importance. This is done by comparing with phenol, a method devised by Rideal and Walker. The minimum concentration of phenol which will kill a twenty four hours' culture of *B. typhosus* in a certain length of time is first determined, and then the concentration of some unknown disinfectant which will produce the same effect under the same conditions is determined. The concentration of the phenol divided by the concentration of the unknown disinfectant gives a ratio called the *Rideal-Walker*

or Carbolic Acid Coefficient of the disinfectant tested. A low carbolic coefficient expressed as a number less than unity usually means that the substance possesses slight disinfecting value.

The British Admiralty Method of determining the germicidal value of a disinfectant fluid is the best, and is done as follows :—

10 c.c. of the fluid is diluted to 1000 c.c. with sterile artificial sea water (32 grms. of Tidman's sea salt in 1 litre of water) and allowed to stand in a cylinder having a diameter of not more than 7 cm. for 24 hours. A portion of this mixture is removed from the middle with a pipette for test purposes, the standard being crystallised phenol also dissolved in artificial sea water.

The organism is *B. typhosus* "Rawling" strain, and the culture grown for 24 hours in standardised nutrient broth at 37°C. The diluting medium is a sterile solution of 0.5 p.c. gelatin in water with 0.5 p.c. finely ground rice starch in suspension. 0.25 c.c. of the culture is added to 5 c.c. of each dilution and shaken. The organisms remain in contact with the disinfectant for 10 minutes, the temperature of the broth and the room being 10° and 18° C. A loopful is transferred to the standardised nutrient broth and incubated at 37° C. for 48 hours and then the record is taken.

The following chemicals are ordinarily used as disinfectants :—

Carbolic Acid Powder.—This is chiefly used as a deodorant but is of questionable value.

Lime.—Quicklime is a most useful disinfectant. A 1 p.c. solution kills non-sporing bacteria in a few hours. A 3 p.c. solution kills typhoid bacilli and a 20 p.c. solution added to fæces disinfects it in an hour. It can be used to purify water, to disinfect stools, floors, etc. It must be fresh and a good sample should not contain any chalk and should not effervesce with dilute mineral acids. For disinfection of stools equal portions should be used and thoroughly mixed with a stick and allowed to stand for two hours. The perfunctory sprinkling of lime over stools is useless. The powder absorbs moisture and CO_2 from the air so that it must be freshly burnt to be of value. As a disinfectant it is used in the form of milk of lime which is prepared in the following manner: 1 quart of small pieces of quicklime is added to $1\frac{1}{2}$ pints of water; this makes a dry hydrate of lime in powder, one pint of which is added to a gallon of water and the resulting milk of lime is utilised for the disinfection.

Perchloride of Mercury (Corrosive Sublimate).—It is a powerful and cheap germicide and destroys all forms of microbic life in relatively weak solutions. A solution of 1 in 1000 kills anthrax, diphtheria, glanders, typhoid bacilli and the vibrios of cholera in ten minutes and in solution of

1 in 500 it destroys spores. There are certain drawbacks to its use, *viz.* (*a*) it acts upon metals; (*b*) its germicidal property is neutralised by its coming in contact with albuminous substances and forming an insoluble albuminate of mercury; and (*c*) it is not a good disinfectant for linens.

It is highly poisonous, and as it forms a colourless and odourless solution it is usually coloured with some harmless aniline dye to avoid accidental poisoning. In the form of tablets it is commonly sold as "soloids" or "solubes," and one tablet in a pint of water forms a lotion of the strength of 1 in 1000.

The addition of acids or salts (hydrochloric or tartaric acid, and sodium or ammonium chloride) prevents or reduces the formation of insoluble albuminates and increases its solubility. These form double salts which are less dissociable and therefore somewhat less active. The Ministry of Health recommended ½ oz. of perchloride of mercury, 1 oz. of hydrochloric acid, and 5 grs. of aniline blue, in 3 gallons of water as an an efficient disinfecting lotion.

Mercuric Iodide is less poisonous, and does not precipitate albumin. Although it is not soluble in water it is dissolved in excess of potassium iodide and sold under the name of mercuric potassium iodide. It can be incorporated with soap. A solution of 1 in 1000 is ordinarily used for disinfection. It is largely used in surgical practice.

The Coal-tar Disinfectants.—These are compounds of (*a*) hydrocarbons and inert oils and bases; (*b*) phenols and phenol-like bodies, *e.g.*, cresols and similar products; and (*c*) emulsifying agents such as soap, resins, albuminoid bodies and water. The germicidal agents in the different coal-tar preparations are the phenols, cresols and their higher homologues. Soaps and resins are employed to help emulsification, but these are easily acted upon by such electrolytes as sodium chloride, calcium salts and organic matter which thus destroy the emulsion. The value of these disinfectants depends upon their power of forming a fine emulsion with organic solutions and salt water. The many commercial preparations on the market vary immensely in their value. They are usually of two kinds, *viz.*, *white*, like izal; and *brown*, like phenyl, the colour being caused by the emulsifying agent used. They form a milky emulsion with water and have the advantage over carbolic acid in being less poisonous and cheaper and ten to fifteen times more powerful.

They should be tested for.—

1. *The Rideal-Walker Coefficient.* Many contain only neutral tar oils.

2. *Their emulsifying power in the presence of salts.* Many which form good emulsions with distilled water hardly emulsify at all if mixed with 1 p.c. salt solution. Such preparations are of small value.

The following coal-tar preparations are used :—

(*i*) *Carbolic Acid* or *Phenol.*—Crude carbolic acid is obtained from distillation of tar. It is very slightly affected by albuminoids, and is generally stable in the presence of organic matter at ordinary temperature. It is poisonous and caustic. A 2 per cent. solution will kill ordinary sporeless bacilli in from a few minutes to ten hours, while it is practically useless for spore-bearing organisms. When dissolved in alcohol or ether, phenol loses its germicidal value, but the disinfecting power is greatly increased by the addition up to saturation of common salt or hydrochloric acid. Its chief value, is as a standard, as its disinfecting power is comparatively low. It is cheap and does not affect metals, but has a caustic effect on the hands, so that it must be applied with a mop or a spray. It is well adapted for mopping floors, side walls and ceilings. As a disinfectant its working strength should be 1 in 20.

(*ii*) *Phenyl.*—It is a very popular disinfectant and is twice as powerful as carbolic acid and has the advantage of being cheap.

(*iii*) *Izal.*—It is an emulsion of higher phenols in water and is a powerful germicide for bacilli of the coli-typhoid group. Eight times more powerful than phenol. A solution of 1 in 500 completely disinfects typhoid stools in fifteen minutes, and 1 in 600 renders typhoid urine aseptic in five minutes. (Klein).

(*iv*) *Cyllin* is seventeen times more powerful than phenol and is cheap and efficient ; useful for disinfecting privies and drains in the strength of 1 in 150.

(*v*) *Hycol* is also a coal-tar derivative and has a pleasant smell. As a disinfectant it is similar to cyllin and is about twenty times stronger than carbolic acid. It forms a dark-brown solution with water.

(*vi*) *Creolin*—It is an emulsified cresol in a solution of hard soap and is about ten times less weak than phenol as a disinfectant. Albumin makes it somewhat inert. It forms a milky solution with water and is used in 2 p.c. solution. Its carbolic coefficient is 3.25 without organic matter, and 2.52 with organic matter.

(*vii*) *Lysol* or Liquor Cresolis Saponatus is a brown, oily-looking, clear liquid. It is a solution of cresol (50 per cent.) in neutral potash soap and is soluble in water. The British Pharmacopœia formula is as follows :—Cresol, 500 mils. ; linseed oil, 180 grms. ; potassium hydroxide 42 grms.; distilled water, q.s. to 1000 mils. A 2 per cent. solution destroys ordinary bacteria in an hour. It is more effective than creolin and is not readily acted upon by albuminous fluids. The working strength of the solution should be 1 in 25. Its carbolic acid coefficient is 2.12 without organic matter, and 1.87 with organic matter.

Potassium Permanganate.—It is a moderate germicide when in strongly acid or alkaline solution, but it stains fabrics brown. It is generally used as a disinfectant in 5 per cent. solution, but in less than a half per cent. solution it acts only as a deodorant. It is expensive and very soon is made inert by organic matter.

Soap is largely used as a popular disinfectant, but its value as such is very limited. It was thought that the alkali present in the soap acted as a germicide, but it is present in so small a quantity as to possess no disinfecting action whatever. In fact apart from being a detergent, soap has no disinfecting power, yet when used with heat accompanied by mechanical cleansing it is of great use as a sanitary measure. Soap should be used with hot water. The addition of caustic alkalies increases its value as a cleansing agent, which is more important than its germicidal action.

A thorough washing of the hands with the formation of a good lather will destroy any adhering diphtheria bacilli, streptococci, and pneumococci. Cocoanut soap is the only soap appreciably active against typhoid bacillus at ordinary temperature. But to kill the bacilli on the hands, the washing should extend over a period of at least three minutes, with the formation of exceedingly stiff lather. This activity is said to be due to its high content of saturated fatty acids and the very low proportion of unsaturated acids.

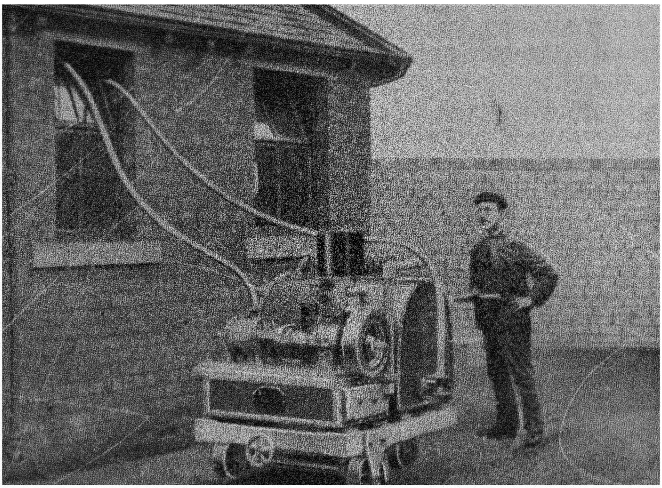

FIG. 141. CLAYTON DISINFECTOR.
Showing room undergoing disinfection.

Sulphurous Acid.—This is used as a gaseous disinfectant and is usually obtained by burning sulphur. It is very

poisonous to mammalian and insect life, and its action as a germicide depends upon the presence of moisture, as the dry gas is practically inert. It is especially valuable for disinfecting ships, cars, granaries, stables, out-houses and places infested with vermin. It bleaches all colouring matters of vegetable origin and many aniline dyes, attacks all metals and acts on cotton and linen fabrics. All the openings of the room should be completely closed and all cracks pasted over with paper, the moisture is supplied by wetting the walls with sprays or by keeping a kettle of water burning. About a pound of sulphur broken and moistened with methylated spirit should be allowed to burn in a vessel. The room should be kept closed for six hours. Two pounds of sulphur when burnt give off slightly over 2 p.c. of SO_2 to the atmosphere of the room and will disinfect a room of 1000 cubic feet. For deratization of ships The International Sanitary Convention does not prescribe standards of concentration and exposure. The American standard is three pounds of sulphur per 1000 cubic feet for a minimum period of 4 hours, but the Ministry of Health recommends a minimum period of exposure of 8 to 12 hours. For fumigation sulphur is used in the following ways:—

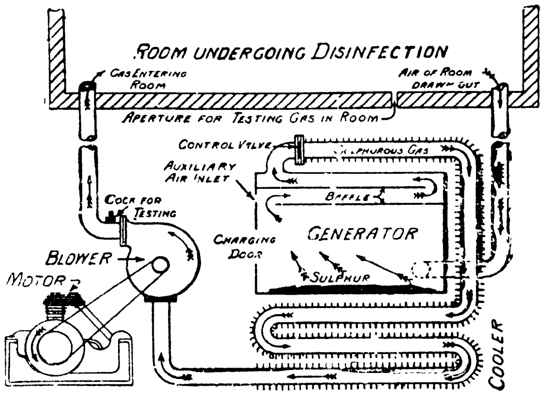

FIG. 142.—SECTION OF A CLAYTON DISINFECTOR.

1. *The Pot Method.*—This is the easiest and cheapest method, and is done by putting powdered sulphur in large iron pots placed in a tub of water. This water furnishes the moisture necessary to hydrate the SO_2. The sulphur is soaked with alcohol and if arranged with a hollow in the centre in the form of a lake it burns quite well. Sulphur candles are available and may also be used. As the gas is heavy the pot should be placed high up in the room.

2. *Liquid Sulphur Dioxide.*—This is rather expensive

but the gas is liberated rapidly. It has the advantage of avoiding accidental fire, and is used only for deratization of small compartments and life boats.

3. *The Clayton Disinfector.*—The principle underlying this method is the generation of special combinations of oxygen and sulphur. This is done by burning sulphur in an iron generator, and the machine abstracts the air from the room to be disinfected by the use of a fan and passes it over burning sulphur. The resulting products of combustion are air cooled by passing through a kind of radiator before reaching the fan. These are then driven through a hose-pipe into the room to be disinfected, the air from which passes back by means of a return pipe to the generator. (Fig. 141 and 142).

The Clayton apparatus is an effective method of using SO_2 and can be adopted without interfering with, or removing the usual contents of a room. The gas generated by it has great penetrating power, and is fatal in time to all pathogenic organisms with the exception of the spores of anthrax. Its chief value is for the destruction of rats, bugs, lice and other vermin and their eggs. The apparatus needs careful attention as the radiation pipes get clogged. The gas is often found to hold a very low percentage of SO_2, about 3 p.c.

Chlorine.—It is an irritant and heavy gas, and the disinfectant and deodorant properties depend on its affinity for hydrogen. Therefore it is essential that a certain amount of moisture should be present. As compared with SO_2 it is slightly more irritant and possesses greater bleaching properties.

For disinfection of a room it is produced by the action of an acid on bleaching powder. The quantity required being two pounds of bleaching powder and one pound of commercial acid for every 1000 cubic feet of space. To insure distribution of the gas the mixture should be put into several vessels and placed high up in the room.

Chloropicrin ($Cl_3 CNO_2$) in concentration of 20 c. c. for every cubic metre of air and acting for 12 to 18 hours was found valuable as an insecticide for adult insects in ships. On the ships it is either evaporated by sprinkling or from rags soaked in the solution and suspended in the room. Rooms must be made air-tight. The vapour has great penetrating power and passes through several layers of cloth and does not affect metals under normal atmospheric conditions. Food articles easily adsorb it and gradually evaporate it. The only drawback is the necessity of prolonged ventilation following its application.

Chlorogen is a hypochlorite fixed in an alkaline solution, and contains 4 to 5 p.c. available chlorine. *Chloros* (hypochlorite of soda) was used by Houston for sterilising water, but to be of any use it must have 12 to 14 p.c. of available

chlorine. In India it is not sufficiently stable to be of any practical use. Hutchinson recently introduced "*Electrolytic Chlorine*" which has a greater stability under Indian conditions, and the available chlorine is low—$2\frac{1}{2}$ to 3 p.c. It is produced by electrolysis of brine and keeping the temperature uniformly low to prevent evolution of chlorine gas.

Chlorine is usually used in the form of *chlorinated lime* or *bleaching powder* which should contain about 35 per cent. of available chlorine. It is an unstable compound and rapidly parts with its chlorine. Every batch of bleaching powder should be tested to estimate the amount of available chlorine. For disinfecting purposes chlorine must always be used in excess. Where the amount of organic matter is small and the objects are not likely to be injured, the hypochlorites are among the best disinfectants when used fresh.

Formaldehyde.—This is used as a powerful disinfectant. For purposes of fumigation formaldehyde has the advantage over sulphurous acid and chlorine in having a lower density which gives it greater power of penetration. It does not bleach textiles or act on metals. Formalin vapour is immensely useful for disinfecting delicate articles such as silks, furs and books. It is also useful for leather goods and kills mosquitoes, fleas and lice.

After the completion of the period of fumigation all the doors and windows should be opened out to allow the gas to pass away. It may be used in the following ways:—

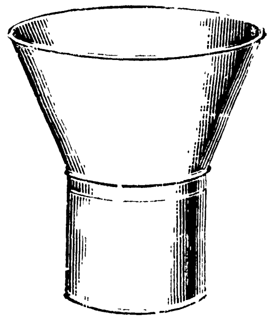

FIG. 143.—TIN BUCKET FOR GENERATING FOMALDEHYDE.

1. *The Permanganate Method.*—For this purpose special tin buckets or jars are used. 5 oz. of potassium permanganate are placed in the jar (for every 1000 c.ft. of space) and then on top of this is poured 10 to 15 oz. of 40 p.c. formalin diluted with an equal volume of water. As soon as the reagents are mixed a violent effervescence takes place, and within a few minutes the whole of the formaldehyde is set free. This gas is very dry and highly inflammable, therefore no naked fire of any kind must be brought near for fear of explosion. The permanganate should not be put on the formalin as there will be a violent explosion. This method is effective, simple, rapid, and by virtue of the inexpensive apparatus required is preferable to the older and more cumbersome methods. There is time for the operator to withdraw. The period of disinfection should be six hours. Heat and moisture are essential for efficient disinfection.

Instead of permanganate of potassium, bleaching powder may also be used. For every 1000 c.ft. of space 2 lb. of

bleaching powder and 2 pints of formalin are required. The bleach is first made into a paste with water and formalin is poured into it.

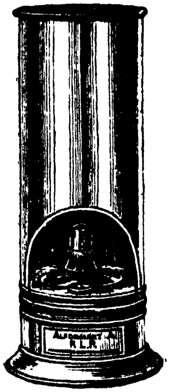

FIG. 144.—PARAFORM LAMP.

2. *The Paraform Method.*—By heating formalin the aldehyde changes into solid polymeride paraform. The gas is generated by heating paraform tablets in a special form of lamp (Alphormant lamp). Usually twenty-five to thirty tablets are required for a room 1000 cubic feet.

3. *Formalin Spray.*—Formaldehyde is also used in solution as formalin and as such is a valuable disinfectant, superior to corrosive sublimate, as its action is not retarded in the presence of albuminous matter. Formalin is a 40 p.c. solution of formaldehyde gas dissolved in water. The solution attacks iron and steel, but not copper, brass, nickel and zinc. It does not bleach fabrics, but renders leather, furs and skins brittle. A ten per cent. solution of formalin in water is as strong an antiseptic as 1 in 500 solution of corrosive sublimate. It is useful for disinfecting water-closets, cabinets, wardrobes, etc.

Hydrocyanic Acid.—This is largely used as a fumigant to destroy rats, fleas and other vermin on board ship, or pumped into rat holes in cases of plague and has practically replaced SO_2 as a fumigant in all the larger ports of United States of America. The gas is generated by adding sodium cyanide, either solid or liquid, to a mixture of sulphuric acid and water in the hold. Cyanogen chloride and *Zyklon-B* are also used and give warning of their presence by the production of severe lachrymation. Zyklon consists of diatomite, a porous granulated siliceous earth, holding its own weight of liquid hydrocyanic acid together with a tear gas. The gas is very poisonous and therefore only a trained staff should be employed who should use respirators. Zyklon-B and liquid hydrocyanic acid have taken the place of the old barrel methods of generating either hydrogen cyanide alone or hydrogen cyanide-cyanogen chloride gas mixture. Liquid hydrocyanic acid is supplied in heavy metal cylinders each containing 75 lbs. of liquid which is transferred to smaller dosing cylinders each holding about 12 lbs. The dosage is 2 oz. for 1000 cubic feet. The staff should always work in pairs and gas masks must always be worn during dosing or subsequent opening up for ventilation. Test animals should first be lowered into the holds before the fumigator goes down to see if the gas is still present. There is still some danger of the gas being absorbed through the clothes and the skin.

Investigation of Infectious Diseases

According to Whitelegge enquiries on the following points should always be made in investigating a case of notifiable disease :—

1. *Patient.*—Address, name, sex, age, date of onset, date of rash, present and past isolation, probable source of infection, recent contact with infected persons or things.

2. *Household* (including patient).—Sex and age of each inmate, susceptibility (as shown by history of previous attack), date of previous attack (if any), occupation, place of work or school and date of last attendance thereat.

3. *Work or business carried on in the house.*

4. *Water-supply* and *milk-supply.*

5. *Sanitary condition* of the premises and surroundings.

6. *Previous cases* of the disease in the house, or in the vicinity, or at the school or place of work.

In dealing with an outbreak of small-pox further enquiry must be made regarding the condition of each individual as to vaccination and re-vaccination, noting the dates. Enquiries about the appearance in the house of rats (dead or living) in cases of plague, should be made.

Spot maps are maps of a district or a town on which death or cases of various infectious diseases are noted on the locality when they occur. They are very important to sanitary officers as they give valuable graphic impressions of any groupings of such deaths or sickness. These epidemic spot maps should be employed for a short period only, since they are not of much value when they cover a period of several months or years.

General Preventive Measures Against Epidemic Diseases

Since the nature and mode of propagation of the epidemic diseases differ from one another, it follows that the measures appropriate for their prevention must necessarily vary. It is, therefore, not possible to lay down any definite and formulated rules that will help the student to cope with all the diseases. Thus, malaria, which is carried by mosquitoes, will require measures quite different from those necessary for diseases like cholera or enteric fever, where the infection is disseminated mainly by the intestinal discharges of the patient. Moreover, the same disease, may at different times, be propagated by different routes. For instance, diphtheria may be spread by personal contact or by the distribution of infected milk. In cases where the disease is conveyed through an intermediary, a knowledge of the bionomics of the animal in question is of great practical value. A campaign against rats and fleas would be useless as a preventive measure without a complete knowledge of their habits. The

same is true for malaria, where a knowledge of the habits of the malaria carrying mosquitoes is equally necessary. To be effective, preventive measures must be based on a knowledge of the etiology of the disease and of its different modes of transmission before effective measures against it can be adopted. Certain general principles which will apply practically to all infectious diseases may be discussed.

In every case of an epidemic it is of primary importance to obtain information of the first cases of the disease. This will enable the sanitary officers to take effective measures against the spread of the epidemic. It is rarely that in an outbreak of an infectious disease the early cases are promptly recognised. In some instances through wilful suppression, more often through want of familiarity with the disease, these cases pass unrecognised. The possibility of the presence of carriers in the affected area should not be lost sight of. These carriers should be detected and suitable steps taken against them. Particular attention should be paid to the poorer classes living in the *bustees* under the most insanitary conditions. Common lodging houses require careful watching in view of the liability of the people who frequent these houses to contract and carry about infectious diseases.

Every care should be taken to localise the infection by preventing unnecessary association of the sick with the healthy. In the event of an infectious disease occurring in a private house, the patient should, whenever possible, be removed to some safer quarter. A room on the top floor, if provided with sufficient windows, should be preferred. Those persons who came into direct contact with the patient should be kept under observation till the period of incubation is over.

Overcrowding should be prevented, and ample ventilation enforced in the sickroom. Refuse should not be allowed to accumulate and the articles requiring disinfection should be disinfected with all possible haste.

The effect of sunlight and fresh air should not be forgotten. Special care should be taken with regard to the excreta and other discharges from the sick. The discharges from the nose and throat of diphtheria, measles, etc., should be treated as infective. The bedding, clothing and other articles which were used by the patient should be similarly dealt with. It is desirable, if not essential, that all these soiled articles should be destroyed by fire ; or else they should be subjected to a thorough disinfection. The stools of cholera and enteric patients should be disinfected before being disposed of or being allowed to pass into house drain or sewer.

Always examine the water-supply. The well or the tank may be polluted by animal refuse, leakage from *kutcha* drains and foul ditches, and washings of infected clothes. Under no circumstances should this water be used for drinking

purposes. If, however, the only source of water-supply is not above suspicion, careful instruction should be given to boil the water before drinking. Ordinary domestic filters should not be relied upon. Arrangement should be made to disinfect the water by suitable means, *e.g.* bleaching powder.

If, however, the infection is traced to the milk-supply, the cleanliness of the cans, the purity of the water used in washing them, the health of the persons engaged in the dairies, the condition of the dairies, the way the milk is stored and carried, require a thorough investigation. In every case insist on boiling the milk before use.

In any campaign against infectious disease success depends largely on the co-operation of the people. It is therefore necessary that they should be acquainted with the precautionary measures which they can adopt against the epidemic which threatens, and what vigilance is necessary with regard to its early symptoms. Printed handbills, placards, popular lectures with magic-lantern demonstrations, and in certain cases house to house visitation by competent and discreet persons may help in quieting unnecessary alarm and assisting the ignorant masses to do what is needful for their own safety.

Practical Methods of Disinfection

The chief point to be aimed at is the efficiency of the disinfectants used and to see that there is nothing to disturb their efficient working. Since success depends upon attending to the minute details, no part of the work should be left to inexperienced persons. The presence of albuminous matters, the nature of the materials to be disinfected, the character of the water used for the dilution of the disinfectant fluid, the strength of the solutions and the mode of application, all require careful attention. Hard water interferes with the property of the disinfectants; soft water should therefore always be used. Disinfectants again act better at a high temperature and are more powerful when in a state of emulsion than when in solution.

Practical disinfection includes disinfection of the sick room, inhabited rooms, persons, clothing, effete materials, dead bodies, bath rooms, etc. And since the infective organisms cannot be seen or located, it is necessary to apply the disinfecting agent to every inch of the surface of the room and all its contents so that the possibility of escaping the particular spot will be nil.

Disinfection of Clothing.—Infected clothes should be disinfected by heat, and the best way of doing it is by boiling for half an hour. Where a steam disinfector is available all infected articles should be sent there in gunny bags previously damped outside with water for proper treatment. They may also be disinfected by immersing them in phenol

5 p.c.; formalin 10 p.c.; or in a solution of corrosive sublimate 1 in 1000. If the clothes are soiled with discharges, as blood, excreta or pus, they require very careful treatment otherwise they will become permanently spoiled by the coagulation of the albuminous matter becoming fixed in the fibres. These should be wrapped in a sheet soaked in sublimate solution and then put in a sack also moistened with some antiseptic lotion. The whole thing is then placed in a solution of soft soap (3 p.c.) and heated to 50°C. for three hours and after two days the contents are taken out and boiled in a solution containing petroleum 10 grms., soft soap 250 grms. in water 30 litres. (Rosenau).

Disinfection of Infected Room.—The methods employed in disinfecting a room will vary with the nature of the infection. Spraying, the use of gaseous disinfectants, or floor washing are the means usually adopted. In case of plague our efforts should be directed against rats, mice, fleas, and the destruction of the plague bacillus; in case of cholera or typhoid fever attention should be paid to the urine, fæces and articles soiled by them. Common articles such as bedding, carpets, rugs, etc., which are liable to be infected, should be treated separately, but should not be removed till disinfection by fumigation is over. These should afterwards be dealt with either by boiling or steam, as gaseous disinfectants do not penetrate enough to render these articles absolutely germ free. Gaseous disinfectants are of little value in cases of Indian huts, as disinfection by fumigation entails closing up of all openings to make the room practically gas-tight. This is impossible in huts on account of their defective construction. These should be disinfected by washing or spraying with some suitable chemical and article after article should be removed and separately dealt with.

In proceeding to disinfect a room the floor should receive attention first, as the germs, the fleas, and the infected materials, *e.g.*, vomitted matter and stool, generally lie on the floor. Even in cases of small-pox the infected particles of skin, which are carried about by the air gradually settle on the floor. Moreover, the custom of sleeping on the ground, especially amongst the poor, makes the floor very infective from the excreta and discharges of the patients. The walls, if necessary, should be disinfected by washing and spraying, and the floor washed with acid solution of perchloride of mercury 1 in 1000, or bleaching powder. In cases of cholera the floor may be disinfected by thoroughly flaming with a painter's blow lamp, or by using freshly slaked powdered lime, bleaching powder or milk of lime.

Disinfection of Privy and Drain.—After disinfection of the room the privy and the house-drain should receive attention. The platform (*i.e.*, the seat arrangement) and the floor of the collecting chamber should be scrubbed and washed

with some antiseptic lotion, *e.g.*, cyllin or chloride of lime, and the privy pan removed and destroyed and replaced by a new one. Subsequently the walls should be lime-washed. The privy requires to be disinfected in cases of cholera, typhoid and dysentery. The house-drain should also be disinfected and thoroughly washed with cyllin or chloride of lime solution.

Disinfection of Excreta and Discharges.—The excreta of certain diseases contain specific organisms and if not properly disinfected or disposed of will be a source of further infection. Thus, the stool and urine of enteric, the sputum of phthisis, pneumonia and pneumonic plague, discharges from the nose and throat of diphtheria and measles, and the vomitted matter and stool of cholera patients require to be carefully disinfected. Carbolic acid 10 p.c., izal 5 p.c., cyllin 1 in 100, or chloride of lime may be used with advantage. But these require contact for 1 to 3 hours. All discharges from the mouth, throat, lungs and nose should be carefully disinfected, and infected rags, etc., burnt. Liquid disinfectants are not particularly good for sputum, nasal discharge, etc. They should be received in gauze swabs and then burned in fire. The stool may be disinfected by one of the following methods :—(*a*) by mixing thoroughly a five per cent. solution of crude carbolic acid, or a ten per cent. solution of formalin with an equal quantity of the excreta and allowing it to stand for one or two hours; (*b*) by mixing with an equal quantity of either freshly prepared milk of lime (1 of lime in 4 of water) or a three per cent. solution of chlorinated lime, and allowing it to stand for two hours. A bucket of boiling water added to a stool and kept covered till it cools will destroy practically all organisms excepting the spore-bearing ones. No infective stool should be allowed to pass into a drain unless mixed with a strong disinfectant for at least three hours.

Disinfection of Miscellaneous Articles.—These also require disinfection. Feeding and cooking utensils should be boiled for fifteen minutes. Immersion in a 20 p.c. hot solution of washing soda suffices for most infectious diseases except in cases of infection by the tubercle bacillus.

Woodwork should be scrubbed with soft soap and hot water, or with perchloride of mercury lotion 1 in 5000 or bleaching powder 1 in 1000.

Table knives and mounted forks, and such other articles that are liable to be damaged by high temperature should be soaked for two hours in a 1 per cent. solution of formalin. Clinical thermometer should be washed and kept in phenol 1 in 20 solution or milk of lime (*see* page 429) for an hour.

Hands are best disinfected by scrubbing with a nail brush and soap and hot water. They may subsequently be soaked in absolute alcohol and finally immersed in a solution of lysol, or perchloride of mercury (1 in 500).

Books, leather articles and other goods should be taken to a small room and then disinfected by formaldehyde gas, the room being kept closed for three to four hours.

Disinfection of Ships.—Before this is done all bedding, linen and personal luggages should be collected and sent for disinfection by steam. Leather articles should be treated with mercury or formalin spray. After removal of passengers the whole ship should be sprayed with mercury, formalin or steam by hose pipe from a tug. Rats in holds should be treated with SO_2 with Clayton disinfector or with hydrogen cyanide (*see* pages 434 and 436).

1. Spraying.—A disinfecting inspector with two men should go with a cart containing gunny bags, a sprayer and disinfectants, and engage themselves as follows :—

1. The bedding, clothes, towels, etc., should be packed in the bags in a previously disinfected place, sealed, and sent to the disinfecting station for disinfection by steam.

2. Fill the disinfector, and spray with the disinfectant the walls, floors, ceiling, crevices and corners ; in fact all receptacles for dirt should be thoroughly attended to. Walls should be scraped before spraying. Spray the walls from below upwards to prevent the solution running down the wall and producing discolouration.

3. Pictures and ornaments should be wiped with clean muslin moistened with a disinfectant solution. They may be sprayed and subsequently wiped dry.

4. Boots, leather goods, fur, silk, brushes, etc., are treated with formalin vapour or sprayed with perchloride of mercury lotion. Books of little value should be burnt or else treated with formalin vapour.

5. Bathroom, spittoons, water-closets, cups and dishes, etc., used by the patient should also be disinfected.

6. Drains should be cleaned thoroughly and treated with a 5 per cent. solution of crude carbolic acid, and all damp places should be sprinkled over with Calvert's carbolic acid powder.

7, Disinfectors should repeat the process over again and then wash themselves.

The disadvantage of this method is the discomfort experienced by the disinfectors in thoroughly carrying out the work. Disinfectors should wear either cotton or waterproof (Mackintosh) coat or overalls which should be left in the room after the work is finished and removed with other articles for steam disinfection. Solutions of mercuric chloride 1 in 1000, formalin 1 in 40, carbolic acid, and lysol are efficient for spraying.

2. Fumigation.—This is an important method for disinfecting rooms, holds of ships, granaries, out-houses, railway carriages, etc., and has a very wide range of application. Formaldehyde, hydrocyanic acid gas and sulphur are chiefly

used for fumigation. The room should be properly prepared by closing the doors and windows and having every joint and window crack sealed with paste and paper. It should not be opened until after at least six hours. And in all cases cultures of test organisms should be exposed in the room as controls.

Fumigation for deratization of ships often fails from lack of penetration of the gas into the dead air spaces, e.g. under floors or into burrowings in insulation. Thus if rats have burrowed into the insulation of cold storage spaces, the burrows must be opened up. Bulk materials absorb HCN gas, specially when moist, even flat surfaces will absorb considerable quantities, the amount depending upon the roughness, porosity, moistness and temperature of the surface. In order that the fumigant may be introduced directly into the dead air spaces a special apparatus should be used. The most successful one is the air jet sprayer in which air under 100 lb. pressure is bubbled through 18 to 30 lb. of liquid HCN in a steel cylinder and thence carried by flexible hose to a nozzle controlled by a trigger. The rat harbourages must be first located and marked before fumigation is started.

3. **Washing**.—This is generally done by means of a sprayer with formalin (6 oz. to 1 gallon of water), solution of liquor cresol saponatus (1 p.c. or $1\frac{1}{2}$ oz. to 1 gallon), corrosive sublimate (1 in 5000), or by hypochlorite of lime solution 1 p.c.

Two other methods of disinfection in connection with infectious diseases should be mentioned here. They are *concurrent disinfection* and *terminal disinfection*.

Concurrent disinfection implies disinfection of all infected materials during the course of an infectious disease. In cases of diseases like measles or pneumonia, where the infection is conveyed by droplets, or in cases of cholera or typhoid, where the infection is carried by the excreta, if the discharges are destroyed concurrently and steps are taken to check the spread of infection by other measures, no further disinfection becomes necessary after the termination of the case either by recovery, death or removal to a hospital.

Terminal disinfection on the other hand signifies the steps taken to destroy or purify the infected materials after the removal of the patient to a hospital, or termination of the case by recovery or death. If, as mentioned above, strict disinfection is done concurrently, the necessity for terminal disinfection becomes less except to destroy the insects or other animal carriers of disease, or some of the personal belongings of the patient like soiled clothing, bedding, mattress, books, toys, etc. Indeed terminal disinfection by fumigation or other means has been discouraged as a public health measure since it has little effect on the control of communicable diseases, and is apt to detract attention from the more urgent and more effective disinfection during the active

course of the disease. It should however be clearly understood that disinfection is an important preventive measure and the destruction of infective discharges during the course of an infectious disease is more important than one final disinfection of the sick room and its belongings.

The principal articles which require disinfection are the discharges from the body, clothing, bedding, feeding cups and other utensils soiled by the patient.

CALCUTTA MUNICIPAL ACT, 1923

Restraint of Infection

Sec. 435.—Every medical practitioner who, in the course of his practice, becomes cognisant of the existence of any dangerous disease* in any private or public dwelling-house, other than a public hospital, shall give information of the same with the least practicable delay to the Health Officer in such form and with such details as the Health Officer may from time to time, require.

Sec. 436.—The Health Officer, or any other municipal officer authorized by him in this behalf, may, at any time by day or by night, without notice, or after giving such notice of his intention as may, in the circumstances, appear to him to be reasonable, inspect any place in which any dangerous disease is reputed or suspected to exist and take such measure as he may think fit to prevent the spread of the said disease beyond such place

Sec. 437.—(1) If it appears to the Health Officer that the water in any well, tank or other place is likely, if used for the purpose of drinking or for any other domestic purpose, to engender or cause the spread of any dangerous disease, he may, by public notice, prohibit the removal or use of the said water for such purpose.

(2) No person shall remove or use for such purpose any water in respect of which any such public notice has been issued.

Sec. 439.—(1) If the Health Officer, or any municipal officer authorized by him in this behalf, is of opinion that the cleansing or disinfecting of any building, or any part of a building or of any article therein which is likely to retain infection, or of any tank, pool or well adjacent to a building, would tend to prevent or check the spread of any dangerous disease, he may cleanse or disinfect such building, part, article, tank, pool or well, and may, by written notice, require the occupier of such building or any part thereof to vacate the same for such time as may be prescribed in such notice.

Sec. 440.—(1) If the Health Officer is of opinion that the destruction of any hut or shed is necessary to prevent the spread of any dangerous disease, he may, after giving to the owner or occupier of such hut or shed such previous notice of his intention as may in the circumstances of the case appear to him reasonable, take measures for having such hut of shed and all the materials thereof destroyed.

(2) Compensation not exceeding the value of the hut shall be paid by the Corporation to any person who sustains loss by the destruction of any such hut or shed.

Sec. 441.—No person shall let a building or any part of a building

* Dangerous disease means (a) cholera, plague, small-pox, cerebro-spinal meningitis and diphtheria, and (b) any other epidemic, endemic or infectious disease which the local Government may by notification in the Calcutta Gazette, declare to be as dangerous disease for the purposes of this Act.

in which he knows or has reason to know that a person has been suffering from a dangerous disease—

(*a*) unless the Health Officer has disinfected the same and has granted a certificate to that effect, and

(*b*) until a date specified in such certificate as that on which the building or part may be occupied without causing risk of infection.

Sec. 442.—(1) The Corporation may provide a place or places, with all necessary apparatus and establishment, for the disinfection of conveyances, clothing, bedding or other articles which have become infected; and when any articles have been brought to any such place for disinfection, may cause them to be disinfected either,—

(*a*) free of charge; or (*b*) in their discretion, on payment of such fees as they may from time to time fix in this behalf.

(*b*) The Health Officer, or any person authorized by him in this behalf, may disinfect or destroy, or, by written notice, direct the disinfection or destruction of any clothing, bedding or other articles likely to retain infection.

Sec. 443.—(1) No person shall, without previous disinfection of the same, give, lend, sell, transmit, or otherwise dispose of any article which he knows or has reason to know has been exposed to infection from any dangerous disease.

Sec. 444.—(1) No person who is suffering from a dangerous disease shall enter, or cause or permit himself to be carried in, any public conveyance, nor shall any other person knowingly cause or permit a person in his charge and suffering from a dangerous disease or the dead-body of any person who has died from such disease to be carried in a public conveyance without—

(*a*) previously notifying to the owner, driver, or person in charge of such conveyance that he is so suffering, and

(*b*) taking proper precautions against spreading such disease.

Sec. 445.—(1) The owner, driver or person in charge of any public conveyance in which any person suffering from a dangerous disease or the dead-body of any person who has died from such disease has been carried shall immediately take the conveyance for disinfection to a place appointed under section 442, sub-section (1).

(2) The person in charge of such place shall forthwith intimate to the Health Officer the number of the conveyance and proceed to disinfect the conveyance.

(3) No such conveyance shall be used until the Health Officer has granted a certificate stating that it may be used without causing risk of infection.

Sec. 446.—(1) The Corporation may provide and maintain suitable conveyances for the free carriage of persons suffering from any dangerous disease or of the dead-bodies of persons who have died from any such disease.

CHAPTER XX

EPIDEMIOLOGY AND PREVENTABLE DISEASES

FROM time immemorial every country has been the seat of visitation of some epidemic disease, and it is probable that no series of natural phenomena, outside death, have affected man psychologically more than the devastating effects of epidemics of fatal disease. They were said to have been the weapons chosen by Jehovah to wear down the hardened heart of Pharoah. The Old Testament also mentions of occurrence of many "plagues". The plague of "Justinian" and the "Black Death" are amongst the most vivid pictures of Europe of the 6th and 11th centuries. Cholera also at various times has spread panic amongst the different nations. Epidemics of syphilis, pneumonia and influenza have appalled generations of men throughout the ages.

It is probable that the first conception of religion was the outcome of these happenings which were thought to be mysterious and due to the hand of retribution, revenge, supernatural agencies, devils and demons. This deistic conception is still prevalent not only amongst primitive peoples but also is not far from the surface in many civilised countries.

Hippocrates in 400 B.C. was probably the first to disabuse the human mind of the deistic idea of epidemic diseases and to apply reason to the study of the phenomena of diseases and epidemics. "No disease" he said "is sent by devils or demons, but is the result of natural causes ; each disease has its own and manifest cause". He conceived a relationship between habit, physique, weather and disease and an epidemic type or state called *katastasis* brought about by the occurrence of certain weather conditions. Varro about 40 B.C. made a distinct addition to the theory by the conceptiôn of minute bodies *animalcula quaedem minuta* arising from marshes or ponds and entering the body by way of the mouth and nose and then causing disease. As time passed, the ratio of theoretical explanation to objective observation grew, until in the Helanistic age it dominated the whole field. In 160 A.D. Galen followed Hippocrates in his teaching of atmospheric influence. Fundamentally Galen's doctrine was logical and self consistent. He held that the generation of a herd sickness depended upon the interplay of three sets of factors, viz. (1) an atmospheriç factor, the *katastasis : (2)* an internal factor, the *crasis ;* and (3) a predisposing or *procatarctic factor.* Given a particular katastasis an epidemic must arise, but whether it

would be great or small depends upon the condition of those exposed to risk, their innate character (the crasis), and their habits of life (the procatarctic factor).

Many centuries later Sydenham (1660) revived Hippocratic ideas and coined the phrase "epidemic constitution" to define conditions of the weather and the land, and of the population, rendering the latter susceptible to attacks of epidemic disease. These constitutions recur at cyclical intervals and are different for each disease. Subsequently Pasteur and Koch's discovery of bacteria as the causative factor of infectious disease directed attention to microorganisms, and variations in virulence and activity of the bacteria apparently offered for the time being an explanation of the periodicity of epidemic diseases. Finally Manson's discoveries of the transmission of filariasis by mosquitoes brought prominently forward the problem of "the means of transmission" and showed that conditions favouring these are also to be taken into consideration. On the other hand susceptibility and immunity both in animals and men are essential factors of the problem and their investigation have brought some additional light.

Gill as a result of observations on the epidemics of malaria in the Punjab advanced the "quantum" theory of the occurrence of epidemics. According to him four factors are necessary to cause an epidemic; they are (1) the reservoir of infection, (2) the parasite factor, (3) immunity factor, and (4) transmission factor. The essential condition for the causation of an epidemic is a loss of equilibrium between infection and immunity resulting from an increase of the infectious "quantum".

The mathematical treatment of epidemics was first initiated by Farr who showed a similarity of the epidemic curve to the "normal" or "gaussian" curve of probability. Ross and Brownlee approached the subject from different angles. Ross's work was fundamentally mathematical and deductive, Brownlee's statistical and inductive. From the mathematical point of view and with regard to its applicability to experimental data Ross's method of approach is more attractive than that of Brownlee. Stallybrass stresses the three factors necessary to cause an epidemic, *viz.* (1) the man himself; (2) the causal agent, *e.g.* malaria parasite, tubercle bacillus, unknown cause of small-pox, etc., as the case may be; and (3) the means of transmission, *e.g.*, water, food, insects, etc. Each of these different factors may be affected by so many diverse causes and conditions, that to investigate, sum up and apportion properly the effect of each factor is an exceedingly complex study.

Within recent years much light has been thrown towards the elucidation of the conditions underlying the occurrence of epidemic diseases by the work of Topley, Greenwood,

Flexner, Webster, and Neufold and Lang. But it should be clearly understood that the spread of disease and the spread of infection, though they may go side by side, are not the same thing. Extensive studies have demonstrated that though there may be wide-spread infection amongst a population, the evidence of actual disease may be few. It is only in the presence of actual disease that the infection becomes manifest. Experimental and observational studies by Topley and others have demonstrated that in controlled herds of mice into which diseased mice are introduced, epidemics of evident disease can only be kept up by the introduction from time to time of fresh susceptible mice. If no new individuals are introduced the evident epidemic dies out. In other words the introduction of susceptibles is an important factor and that the character of the epidemic is largely influenced by the numbers and the rate of immigration and susceptibles. This observation is of special significance as by such means epidemics can be kept up for an almost indefinite period. The effect of adding fresh susceptibles to a population which has just adjusted itself in the struggle between the infecting agent and the hosts is to provoke a fresh outbreak which involves not only the added ones but also the original survivors; so that from the point of view of the latter this immigration is undesirable. It will therefore be evident that by such inter-reaction these epidemics lose their self-limiting character and tend toward extermination of the infected population. When a disease spreads in an epidemic form a series of reactions between the host and the parasite occurs, by the interplay between the microbic virulence and the resistance of the host. On the other hand when an epidemic tends to be self-determined, and comes to an end after producing a certain mortality in the population, it is evident that those who survived must have been in possession of a superior degree of resistance either developed during the exposed period or were endowed with it from the beginning of the experiment. Topley by examination of the various survivors in the herds of mice demonstrated the presence of organisms in the spleen although to outward appearance they looked healthy. It is evident therefore that these survivors were definitely infected but the infection was non-effective, and it is possible that the immunity was established at the expense of some sort of symbiosis. Dudley, by observing (during epidemics of diphtheria and during non-epidemic intervals) the number of actual cases of diphtheria, the number of sub-infective cases (temporary carriers) and the number of susceptibles and non-susceptibles, also confirmed Topley's views as to the recrudescence of epidemic by the introduction of susceptibles. He further assumed that a minimum quantum of the infective agent was necessary to produce evident disease, and that this quantum might be

delivered to the recipient all at once, or by driblets at intervals of time, until the sum of the portions reached the necessary amount to produce disease. As Dudley states, if V is the amount of infective material delivered per hour and U the amount destroyed by the recipient per hour, then

(1) If $V - U$ is negative and the velocity of infection low (only at long intervals) there may not be sufficient reaction to give any acquired immunity.

(2) If the velocity of infection is slightly more rapid, acquired immunity may occur without any infection.

(3) If more rapid still, acquired immunity is obtained, but the organism can establish itself on the host = acquired immunity *plus* the carrier state.

(4) If still more rapid, disease occurs, but in atypical form and often not recognisable as such.

(5) Still more rapid—typical cases of the disease occur with recovery.

(6) Still more rapid or large initial dose—disease and death.

The reason for the rise and fall of epidemics is still a matter of speculation. The infective power of the micro-organisms and the susceptibility of the population at risk no doubt play important parts, and it is possible that either the one or the other or both together may be dominant factors in influencing the rise or fall of an epidemic as the case may be. Besides the loss of infective power there are possibly other factors for the decline of ep demics. On the other hand the epidemic often helps to develop a certain amount of immunity amongst the population at risk and thus acts as a check on the further spread of the infection. This is known as "epidemic immunisation." D'Herelle and his co-workers believe that at least in cholera the dissemination of bacteriophage by convalescents is the main if not the only cause of the decline of an epidemic of cholera in India. The following factors also influence epidemic diseases, viz.—

Soil and rainfall.—Varro first associated disease with marshes, and we know that malaria occurs in swampy districts where mosquitoes can breed, although the disease can occur in dry places provided there are sufficient collections of water for the breeding of mosquitoes. Rainfall is usually favourable to the occurrence of malaria and Gill in the Punjab for several years has successfully predicted the malarial incidence in autumn by a study of the rainfall in July and August. A moist ground helps the hook-worm to complete its life cycle. Growth of bush combined with slight humid surface attracts the tsetse fly which carries sleeping sickness. Rogers by studying the epidemics of cholera in various parts of India during forty-five years and comparing them with the rainfall in the same areas, found that forty out of forty-one epidemics were preceded by the failure of rains of the previous monsoon or

of the winter rains, or frequently of both. Moreover a rise of the absolute humidity favoured early recrudescence or spread of epidemic cholera. By watching these two factors Rogers was able to make forecasts with reasonable certainty several months before epidemic outbreaks.

Season.—Most infectious diseases are seasonal. Thus whooping cough, small-pox, measles all occur during the first quarter of the year carrying over to the second. Malaria generally occurs during the later months of the rainy season, specially in the warm season which comes between the rains and the cold weather. Plague is another example of seasonal disease. It diminishes during the height of the hot season due to high temperatures and high saturation deficiencies. Seasonal prevalences are also observed in cholera. In Assam, Bengal and South East Madras it shows an increase during the months of October to December, and decreases in January and February. It remains prevalent during the humid monsoon period of June to September all over India, except flooded Bengal and Assam, and declines in the autumn in North-west and Central India.

Economic conditions.—It has been observed that many diseases are influenced by the standard of life in communities. Tuberculosis is highly common amongst the poor who live in insanitary, ill-ventilated and badly lighted houses in overcrowded localities under conditions which favour the spread of the disease by droplet infection. Economic conditions play an important part in the intensity of malaria. Typhus fever, which is spread by lice and ticks is fostered by overcrowding and low conditions of living. War in all ages has brought disease in its train.

Human intercourse and travel.—When susceptible persons are aggregated together, the conditions become favourable for the spread of infection. This is true of many diseases, *e.g.* measles, small-pox, malaria, and cholera are all fostered by human intercourse. Travel is a factor of considerable importance in epidemiology. It has been said that oversea traders from Rome brought malaria to Italy to which the fall of the Roman Empire has been attributed. The pandemics of influenza in 1918 and 1928 are an illustration of the part played by travel. The paths of infection from one country to another coincide closely with the established lines of human travel, and the rate of propagation is determined by the speed of such travel. Within recent years the facilities of air travel have made it possible for persons to land in uninfected countries while incubating infections contracted in an infected country. There is also the possible contingency of accidental carriage of infected mosquitoes to places where such infections are unknown.

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Diseases Carried by Insects

Malaria

Malaria is a specific infectious disease caused by a sporozoon parasite, and carried from man to man by the agency of certain species of anopheline mosquitoes. In man the parasites attack the red blood corpuscles, and give rise to pyrexia exhibiting a characteristic periodicity, accompanied by enlargement of the spleen, and followed, if inadequately treated, by anæmia and cachexia in varying degree. A feature of the disease is its tendency to relapse at intervals over a period of months, or even years.

Geographical Distribution.—Malaria is a wide-spread disease thioughout the tropics and sub-tropics, where it is more prevalent than in temperate climates. In Europe it exists chiefly in the countries bordering on the Mediterranean and in South Russia. It is widely distributed in tropical and sub-tropical Africa and South and Central America, whilst in Asia it occurs with varying degrees of intensity throughout Mesopotamia, India, the Malay Peninsula, the Dutch East Indies, Indo-China, Southern China, etc. Australia and Japan enjoy comparative immunity from this disease.

The Importance of Malaria.—Osler's oft-quoted dictum that malaria is probably the greatest single destroyer of the human race is by no means exaggerated. In India it is estimated that this disease is directly responsible for over one million deaths per annum. During the great epidemic of 1908 it occasioned over 300,000 deaths in the Punjab among a population of approximately 20,000,000. Apart, however, from actual mortality a vast amount of ill-health is caused by malaria, whilst those debilitated by attacks of this disease become easy victims of other infections. In addition to the suffering and loss of life entailed, the disorganisation of labour due to malaria makes it an economic factor of the highest importance, a fact well recognised by commercial firms, such as those controlling tea and rubber plantations and engineering concerns, who suffer grave financial embarrassment from disorganisation of work and expenditure on medical treatment and preventive measures.

In certain very malarious parts of the world, whole tracts of fertile country have been abandoned owing to the ravages of malaria, whilst the construction of railways and harbours and other industrial projects have frequently been held up or gravely interfered with owing to the amount of sickness caused by the disease amongst the staff employed.

The Incidence of Malaria.—Malaria is a seasonal disease,

the time of maximum prevalence in most parts of India being the autumn months, from August to November. This seasonal rise is more marked in the dry north-western tracts of the country, where the conditions favourable for transmission are limited to a comparatively short period of the year. It is these areas too which are liable to outbreaks of malaria in epidemic form, which are especially likely to occur in years when there is a heavy rainfall in July and August following a year of economic stress. The essential feature of this type of malaria is a sudden temporary rise in the death-rate. In other parts of the country, such as Assam, Bengal and Southern India, where the climate is humid and the amount of annual rainfall very high, these epidemics do not occur, but there is a varying degree of endemic malaria, *i.e.*, the amount of malaria is more or less static among the population. In hyper-endemic areas the proportion of children showing enlargement of the spleen may approach 100 per cent. Such areas exist particularly in submontane tracts, such as the Nepal Terai, Bengal Duars and the Jeypore Hill Tracts of Madras. The occurrence of black water fever among susceptible immigrants is an indication of a very high degree of malarial endemicity.

Most of the malaria-carrying mosquitoes breed in streams, pools by the side of streams, seepages from hillsides, small irrigation channels, etc., and it is probably the presence of numerous mountain streams producing large numbers of these species which accounts for the high incidence of malaria in submontane regions referred to above.

The mere presence of swampy or flooded areas does not necessarily make for a high incidence of malaria as is popularly supposed; indeed, in many such regions malaria is practically non-existent, as for example, the Howrah District in the extreme south of Bengal, and the northern part of the Island of Bombay.

Malaria is chiefly a rural disease, the reason being that very few of the malaria-carrying species of anophelines are able to adapt themselves to urban conditions. There are, however, certain exceptions to this rule, notably the case of *A. bifurcatus* in Palestine and *A. stephensi* in India. As has been noted elsewhere (*see* page 364), *A. stephensi* will breed freely in wells, cisterns, fountains and garden tanks, and even in disused tins or earthenware vessels containing water. This species is notorious as being the insect transmitter of malaria in Bombay and other cities.

Immunity in Malaria.—Beyond the fact that as is the case with other diseases certain individuals are more susceptible than others to infection, there is no such thing as a natural immunity to malaria. Immunity when present is almost invariably a partial immunity, acquired as the result of repeated infections and re-infections occurring over a

long period. Infection with one species of malaria parasite confers no immunity in respect of any other species. Furthermore, researches on induced malaria for the treatment of nervous diseases and on malaria in monkeys have shown that there are many different strains of the various species of malaria parasites, though they are morphologically indistinguishable. An individual who has been infected with one strain of parasite will acquire an immunity to that particular strain, but not to other strains of the same parasite, except to a very limited extent. Presumably in a malarious locality, the inhabitants in childhood gradually acquire their partial immunity by becoming infected successively with all the various local strains. The researches of Schuffner and of Christophers have shown that in a very malarious locality children for the first two years of their lives are in a condition of "acute infestation," almost all of them suffering from fever and showing large numbers of parasites in their blood. This is succeeded by a period of "immune infestation," in which parasites though still present are in greatly reduced numbers, and attacks of fever occur at longer intervals, though the percentage showing enlargement of the spleen is very high. In adult life the parasites, though still present in many cases, are very scanty, the number of persons with enlarged spleens is greatly reduced, and the people are comparatively free from clinical symptoms of the disease. There is thus a definite acquired immunity in malaria, comparable to the "salting" of animals in trypanosomiasis and piroplasmosis.

The Parasites of Malaria.—The causal organisms of malaria are members of the genus *Plasmodium*, which belongs to a class of the protozoa known as sporozoa. Four species are generally recognised as being concerned in the production of human malaria, *viz. Plasmodium vivax*, the parasite of benign tertian malaria; *Plasmodium falciparum*, the parasite of malignant or subtertian parasite; *Plasmodium malariæ*, the parasite of quartan malaria; and *Plasmodium ovale*, a parasite which produces a mild form of tertian malaria. The last named is found in Africa, and has not yet been recorded in India.

The life-history of the four parasites is in each case essentially the same. They undergo two cycles of development, an asexual cycle in man (*schizogony*) and a sexual cycle in the mosquito (*sporogony*). The mosquito is thus the definitive and man the intermediate host.

The young parasite, as found in the red corpuscles of the human blood, is known as a *trophozoite*, and when stained and examined under a microscope appears in its earliest stage as a small ring of protoplasm with a dot of chromatin, occupying only a small portion of the cell. The parasite increases in size, pigment appears, and after a time the

chromatin begins to divide, when it is known as a *schizont.* The schizont when mature, at which stage it appears to occupy the whole or greater part of the cell, splits up into a number of small bodies called *merozoites.* These are liberated by the rupture of the infected cell, and attach themselves to other red corpuscles. The process is then repeated, and constitutes the asexual cycle, or *schizogony.**

Sooner or later some of the young trophozoites, instead of becoming schizonts, grow into male and female forms

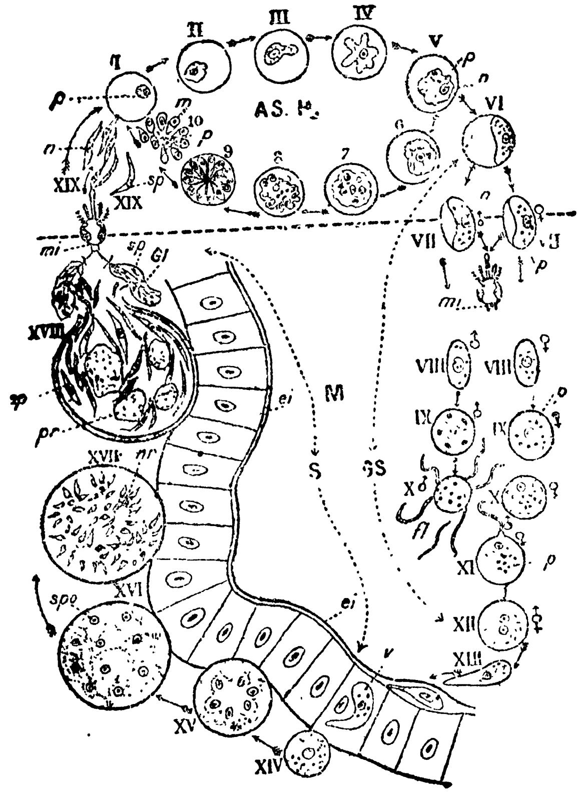

FIG. 145.—THE MOSQUITO CYCLE.

AS. H. Cycle occurs in the patient's blood; The portion below the dotted line shows the sexual cycle in the body of the anopheles. VII, gametocytes; VIII-X, gametes; XI, male microgamete entering female gamete (macrogamete); XII, zygote or ookinet; XIII, travelling vermicule; XIV-XVII, oocyst; XVIII, rupture of oocyst with liberation of sporozoites, sp.

* Some authors consider that the malarial parasite never actually penetrates the red cell, being situated throughout on its outer surface.

alled *gametocytes*. These are incapable of further develop-ient unless they are taken up by the bite of a female ano-heline mosquito. In the stomach of the mosquito the male nd female forms escape from the red blood corpuscles, nd are now known as *gametes*. The male gamete extrudes iinute filaments (*microgametes*) one of which enters a female amete to form a body known as an *ookinet* or *zygote*. This ssumes an ovoid form (the *travelling vermicule*) and pene-rates the wall of the mosquito's stomach, coming to rest etween the epithelial and muscular layers. Here a cyst is ormed around it, and it is known as an *oocyst*. This increa-es in size, and in it are formed a vast number of tiny bodies alled *sporozoites*. The cyst ruptures, and these are liberated ito the body cavity of the insect, and a number of them make heir way to the salivary glands. When the mosquito again akes a blood meal she injects salivary fluid as she sucks up lood, and thus the sporozoites are introduced into the cir-ulation. They attach themselves to red corpuscles and ul-imately enter them, becoming trophozoites identical with hose described in the account of the asexual cycle.

In the case of malignant malaria schizogony takes place n the internal organs, and except in very grave cases it is xtremely rare to find parasites other than ring forms or ametocytes in the peripheral blood. The gametocytes in this ype of malaria are crescentic in shape, a form not found in ither benign tertian or quartan infections.

The asexual cycle in all forms of tertian malaria is com-leted in 48 hours, and in quartan in 72 hours. The sexual ycle in the mosquito occupies under favourable conditions bout 12-21 days, but development is greatly delayed at low emperatures. It is possible for an anopheline female to emain infective for several months, at any rate, under iboratory conditions.

In all forms of malaria the fever is as a rule quotidian at he beginning of a primary attack, but in the tertian forms it iter occurs on alternate days, whilst in quartan it occurs very fourth day, *i.e.*, two days intervene between each bout f pyrexia. Benign tertian and quartan malaria, though not angerous to life, are the most persistent forms, and relapses re very common. Malignant tertian malaria is much more menable to treatment, but as its name implies it may occur n very grave and even fatal forms. The fever produced by *Plasmodium ovale* is both mild and easily amenable to treat-ient. All forms of malaria if untreated result in chronic nlargement of the spleen, anæmia and general cachexia.

Etiology.—From the above account of the life-history of he malaria parasite it will be readily understood that there re many factors concerned in the spread of the disease. The most important of these are briefly discussed below.

(*i*) *The Source of Infection.*—For the transmission of the

disease the presence of individuals with a sufficient number of gametocytes in their peripheral blood is necessary. In a malarious community it is the children who constitute the chief reservoir of infection.

(*ii*) *The Anopheline Factor.*—Only certain species of anophelines are capable, under natural conditions, of acting as efficient transmitters of the disease. It is necessary, therefore, for at least one of these species to be present in sufficient numbers, and for there to be breeding places in the neighbourhood suitable for the particular species.

(*iii*) *Climatic Conditions.*—It has been shown that certain meteorological conditions are necessary for the transmission of malaria, the most important of these being temperature and humidity. The malaria parasite ceases to undergo development in the midgut of the mosquito when the mean temperature remains permanently below 16° C. (60.8° F.), the optimum conditions for the transmission of the disease being approximately represented by a mean temperature of 20° to 30° C. (68° to 86° F.) in association with a mean relative humidity (8 a.m. reading) of 63 per cent. or more. Atmospheric humidity exerts a most important influence on the incidence of malaria, though it has no *direct* effect upon the parasite in the mosquito. We have already seen that when the relative humidity is high mosquitoes are more active, and feed more voraciously. A high relative humidity also lengthens the life of the mosquito, thus enabling it to live long enough for the complete development of the malaria parasite within it, whilst by checking the rapid radiation of heat from the surface of the earth it tends to maintain an equable temperature favourable to the uninterrupted development of the plasmodium in its insect-host (Gill). The association of malaria with rainfall is probably due more to the concomitant rise in relative humidity than to the fact that more breeding places are provided for mosquitoes.

From the above considerations it will be readily understood why in certain regions the period of the year during which transmission of malaria is possible is much longer than in others; and why the disease is especially prevalent at certain seasons of the year.

(*iv*) *The Presence of Susceptible Individuals.*—It is a well-known phenomenon in the tropics that the introduction of susceptible persons, such as a body of labourers or troops, into a malarious community almost invariably results in an outbreak of malaria. This is probably due to the infection of the new-comers by a strain of malaria parasite to which they have no immunity. Not only are the new-comers attacked, but the disease appears to acquire an enhanced virulence among the local inhabitants. This is sometimes known as "the factor of non-immune immigration".

(*v*) *Economic Conditions.*—Insufficient food, overcrowding

and exposure to privations generally have an important bearing on the incidence of malaria. It was shown by Christophers in the case of the Punjab that on several occasions a year of famine (if succeeded by a year of excessive rainfall) has been followed by a severe epidemic of malaria.

(*vi*) *Malaria and Irrigation.*—The introduction of irrigation affects the incidence of malaria in various ways. By improving the economic condition of the people it tends to exercise a beneficial effect. The question of the bearing of irrigation on malarial incidence is, however, a complicated one, and its effects vary with the type of irrigation employed, and with the climatic and physiographical characters of the country. In the Punjab, where perennial irrigation is largely employed, it has been shown that leakage from canals or inadequate drainage of the region irrigated may result in water-logging of the soil and an increase in malaria. Even in the absence of water-logging it has repeatedly been proved that where the subsoil water level has been raised by irrigation the incidence of malaria has increased. Hence the importance of adequate systems of drainage in connection with irrigation projects (*see* page 124). Dangerous anopheline mosquitoes frequently breed in the small irrigation channels which carry the water to the fields.

In Lower Bengal, where inundation irrigation is the rule it has been shown that those areas which are regularly flooded by this method are least malarious, whilst those protected from flooding by embankments suffer most. Bentley holds that the adoption of a comprehensive scheme of irrigation from the main rivers will be an efficient method of controlling the incidence of malaria in this part of India.

(*vii*) *Malaria and Rice Cultivation.*—The effect of rice cultivation on the incidence of malaria varies markedly in different localities. Submontane tracts, where rice is grown in terraces, are usually intensely malarious. In those parts of Bengal where the whole countryside is flooded during the monsoon, and the rice fields are covered with several feet of water, malaria is very slight, but in districts where they are only covered by a few inches of water in the rainy season the disease is usually extremely prevalent.

In Sind the rice-growing tracts which are heavily irrigated are highly malarious. Here it is customary to drain off the water in which the rice is growing at frequent intervals, in order to get rid of the salts with which it becomes impregnated from the soil into any low-lying ground that may be at hand. This is known as the "Pancho" system. The breeding of dangerous anopheline mosquitoes does not occur in the rice-fields themselves, nor in the water first drained off from the rice-fields, but profuse breeding occurs in the water subsequently drained off, which contains a lower percentage of salts.

In the Central Provinces, on the other hand, vast areas under rice cultivation are practically free from malaria. Rice cultivation in this province is only harmful when accompanied by irrigation in the neighbourhood of jungle. The malaria-carrying anophelines do not breed in the rice-fields, but in the irrigation channels, streams, pools in the beds of nullahs, etc.

Thus it will be clear that it is not the fact that rice is being cultivated that determines the incidence of malaria, but the character of the surrounding country, and the different methods of cultivating the crop.

(*viii*) *Man-made Malaria.*—It has already been noted that man may increase the incidence of malaria by the introduction of irrigation without proper attention to drainage. The natural drainage of the country is also frequently interfered with by the construction of railway embankments and roads without sufficient culverts. Sources of mosquito breeding are provided by man in the shape of borrow-pits in connection with railways and roads (*see* page 123), improperly constructed street gutters, non-mosquito proof wells and cisterns, fountains, garden tanks, leaky hydrants, water-troughs, fire buckets, etc.

Malaria Surveys.—Before attempting to put into practice measures for the prevention or control of malaria, a preliminary survey is essential. The object of this is first to ascertain the amount of malaria existing, secondly to investigate the factors concerned in the causation of the disease in the particular locality in question, and finally to devise practical measures for its amelioration, having due regard to the financial issues involved. Without a properly conducted survey an immense amount of money may be wasted, as for instance, on measures directed towards the abolition of collections of water or swamps which may be harbouring an entirely harmless species of anopheline, whilst the less obvious breeding places of dangerous carrier species may have been overlooked.

(*i*) *The Measurement of Malaria.*—This is best done by an examination of as many children as possible under ten years of age who have been born and brought up in the locality for enlargement of the spleen and for parasites in the blood. The percentage of children showing enlargement of the spleen is known as the *splenic index*, and the percentage showing parasites in the blood as the *parasite index*, or *endemic index*. The size of the spleen may be measured in terms of finger-breadths below the costal margin, but more accurate information may be obtained by Christophers' method of triangulating the exact position of the apex of the spleen by measurements in centimetres from the umbilicus and middle line of the body, and entering the results on a special abdominal chart. Similarly the number of parasites

per cubic millimetre of blood may be estimated by Sinton's fowl-cell method. Both of these methods are capable of application in the field, and the slightly longer expenditure of time involved is amply repaid by the greater exactitude of the results obtained.

Further information as to the incidence of malaria may be gathered from a study of the mortality figures for the district, and from the examination of dispensary and hospital records and the statistics relating to jails or troops stationed in the area. By these means the seasonal prevalence of malaria, the actual morbidity and mortality and any evidence of epidemic prevalence may be ascertained.

(*ii*) *Investigation of the Factors Concerned.*—This includes the incrimination of the species of anopheline concerned in transmission by dissection. The important point here is to determine the percentage which show sporozoites in the salivary glands, and are thus capable of allowing the complete development of the parasite. This is known as the *sporozoite index.* Even though no infected specimens may be discovered at the time of the survey, the presence of proved carrier species of anophelines in a malarious neighbourhood will afford strong presumptive evidence as to the vectors concerned in transmission. The next point is to make an intensive study of the breeding places and bionomics of the suspected carriers. Other points to be investigated are the physiographical features of the country, the meteorological conditions, presence or absence of irrigation, type of cultivation, the economic condition of the people, the presence of susceptible immigrants, etc.

(*iii*) *The Formulation of Preventive Measures.*—These will of course depend on the conditions which have been revealed by the results of the survey, and will be very largely determined by the financial resources available. It is obviously absurd to recommend measures which the authorities concerned cannot carry out through lack of funds, and it is of great value to produce a balance-sheet showing on the one side the estimated sum lost annually from malaria by interference with labour, loss of wages and expenditure of treatment of the sick, and on the other the amount which it is proposed to spend on preventive measure. Business firms, such as those controlling tea or rubber estates or engineering works, are quick to see the force of such an argument, but it must be admitted that it is often difficult to persuade other local authorities to spend money on antimalarial measures, even when it is pointed out that such expenditure will be a sound financial investment.

Methods of Prevention and Control.—From what has been said regarding the ætiology of malaria it is obvious that if any of the following conditions could be fulfilled the disease would cease to exist:—

(*i*) The extermination of those species of anopheline mosquitoes which transmit malaria in nature.

(*ii*) The complete protection of the population against the bites of such mosquitoes.

(*iii*) The destruction of the malaria parasites in the blood of all infected persons, so that no more gametocytes could be produced.

Bearing these considerations in mind it is convenient to discuss preventive methods under the following headings :—

A. Protection against the bites of mosquitoes.
B. Destruction of adult mosquitoes.
C. Destruction of mosquito larvæ.
D. The use of drugs.
E. Improvement of economic conditions.

A. Protection against the Bites of Mosquitoes

(*i*) A *mosquito net* should invariably be used in any locality where malaria exists, whatever other precautions may be adopted. The netting used for British troops in India is woven of 30/s cotton and is of 25/26 hole mesh. The best pattern is the rectangular net, with no opening in it for the purpose of entering, and it should be hung inside the poles and tucked continuously all round under the mattress.

(*ii*) *Mosquito boots* are very useful to protect the ankles in the evening. They may be made either of soft leather or of canvas. Wellington boots may also be used for this purpose.

(*iii*) *Veils* and *Gloves* are sometimes used to protect men on guard at night.

(*iv*) *Repellents or Culicifuges.*—The common drawback of all these is that after a certain length of time their effect wears off; but they have their value when men have to be out at night for limited periods in malarious situations, or on railway journeys. Many different preparations have been used for this purpose, one of the most useful being a pomade of the following composition, *viz.* oil of citronella ½ oz., spirit of camphor ¼ oz., cedar wood oil ¼ oz., white petroleum jelly 2 oz.

(*v*) *Screening of Buildings.*—The value of this method of protection is generally recognized in America, Italy and the Federated Malay States, and of recent years it has been used in some of the barracks of British troops in India with excellent results. It is essential that the building to be screened should be well-constructed and in good repair, that every aperture in it should be screened, and that doors should fit well and not sag on their hinges. Double doors, with a porch or vestibule at least six feet in length between them, are a great advantage, and all doors should be made to open outwards, to prevent mosquitoes resting on the outer surface of the gauze from entering the building. The gauze used in the barracks of British troops in India is of 14 mesh

and 28-30 S.W.G. giving an aperture of 0.055 to 0.057 inch. This is sufficient to exclude *A. culicifacies* and probably all other malaria carrying mosquitoes.

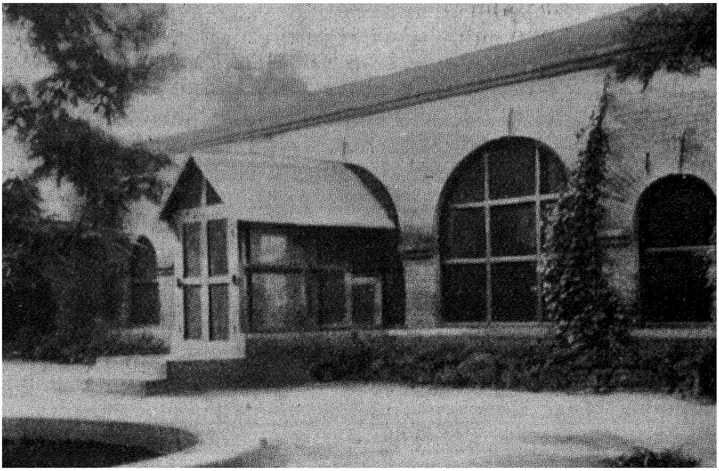

FIG. 146.—SCREENED VERANDAH AT THE EXPERIMENTAL FIELD STATION OF THE MALARIA SURVEY OF INDIA, KARNAL, PUNJAB.

The material used may be of galvanized iron, which is cheapest, but this cannot be employed if the building is near the sea, and is also unsuitable if the atmosphere is constantly very humid. Brass, copper or phosphor bronze last much longer but are considerably more expensive. MacArthur recommends the use of "monel metal." which is a natural alloy containing nickel 57 per cent., copper 28 per cent., and other metal 5 per cent. Good results have recently been claimed for a gauze screen made of aluminium. The essential point about screening is the thoroughness with which it is done, and frequent inspection is necessary, especially where there is extreme variation in humidity between the wet and dry seasons, leading to the development of defects in the wooden framework.

B. Destruction of Adult Mosquitoes

(*i*) *By Hand.*—In view of the fact that recently fed and therefore possibly infective mosquitoes may be killed in this way, this is a method of considerable importance. *Swatters*, consisting of a piece of wire gauze fixed to a wooden handle are effective, and children may be taught to use them.

(*ii*) *Traps.*—There are many forms of these, perhaps the most useful being in the form of a simple box or wire frame, some two to three feet square, lined with black or dark blue

material. One side of the box is left open at night and closed in the morning. A considerable number of mosquitoes may be caught in this way.

(*iii*) *Fumigation.*—Various fumigants have been employed, the most generally effective being sulphur (1 lb. to 1,000 cubic feet) and cresol vapour (4 to 5 ounces of cresol solution per 1,000 cubic feet). Before fumigation is carried out, all chinks in the doors and windows must first be closed by pasting paper over them. If there are glass windows in the building, it is a good plan to leave one of these uncovered, and to place a white sheet on the floor beneath it. Mosquitoes will fly towards the light in their endeavour to escape, and will fall on to the sheet, when they can be swept up and burnt. This will obviate the danger of any of the insects recovering from the fumes.

(*iv*) *Sprays.*—There are a considerable number of proprietary sprays on the market, most of them containing a proportion of kerosene oil. An effective spray which can be made for one quarter the cost of most of the proprietary sprays can be made as follows :—Powdered pyrethrum 60 gm., chloroform 120 c.c. The mixture is well shaken in a bottle for two hours, then filtered. The resulting filtrate is made up to one litre with kerosene.

(*v*) *Cutting down of Jungle and other Vegetation.*—Some species of anophelines spend the day-time hidden among long grass or in bushes and other coarse vegetation and the clearing away of these in the vicinity of dwellings is therefore of value in the campaign against adult mosquitoes.

C. Destruction of Mosquito Larvæ

The methods adopted will depend on the particular conditions obtaining in the locality, on the species of anopheline which has been incriminated as the carrier, and on the amount of funds available. Other things being equal, permanent measures, *i.e.*, complete eradication of breeding places, should be carried out wherever possible, temporary measures such as the application of larvicides or oil only being justified either when the cause itself is temporary, or the cost of permanent measures prohibitive.

(*i*) *Clearing of Jungle.*—This promotes evaporation and therefore the drying up of collections of water, whilst it also may disclose breeding places which would otherwise be overlooked. It must be borne in mind, however, that certain dangerous malaria carriers (*e.g. A. maculatus*) prefer breeding places exposed to sunlight, so that indiscriminate removal of jungle in areas where such species exist may have disastrous results. In Assam, where *A. minimus*, a species which prefers sun-lit breeding places, is the principal malaria carrier, the growing of shade-giving plants over streams, drains and swamps, has been practised in certain tea estates with beneficial results. This method can only be employed,

however, in localities where the population is under strict control, for the least break in the shade is fatal to success.

(ii) Drainage.—This large and important subject cannot be treated fully here. Some of the chief points are briefly mentioned below.

(*a*) *Open Drains* may be employed to deal with dangerous swamps, seepages, etc. They should be narrow and deep rather than broad and shallow; their banks kept free from vegetation and sloped to an angle of 45 degrees; tributaries should enter them at an acute angle, not at right angles; the bottom of the drain should be rounded and not V-shaped. It is an advantage to construct drains with a central deeper channel or *cunette* to take the water along quickly when its level is low. Contour drains on hill slopes are useful in dealing with seepage water, but it is usually necessary to treat these systematically with larvicides.

(*b*) *Subsoil Drains.*—The drain in this case is formed by a series of tile pipes laid end to end, the water entering at the joints between the pipes. These are usually from 6 to 12 inches in diameter, of circular bore, and laid in a trench several feet below the surface of the ground. The trench is then filled in with stones to a height of a few inches above the original ground surface. This type of drainage has been found most effective in dealing with hill streams and seepage outcrops, but its cost is high. In the case of plantations a disadvantage is that all trees have to be removed for a considerable distance from the drains, otherwise the latter become choked with roots. This waste ground, together with the heavy cost of upkeep, has resulted in the owners of many estates in Malaya abandoning subsoil draining, and reverting to open drains and oiling.

(*c*) *Drainage and Irrigation.*—It is essential that any irrigation project should include an adequate scheme of drainage; otherwise the result will be water-logging of the soil and an inevitable increase of malaria. This is a subject which can only be dealt with by the irrigation engineers, but it is the duty of the malariologist to point out its importance from the point of view of public health.

The prohibition of canal irrigation in the immediate vicinity of towns and villages has in certain instances resulted in a great diminution of malaria in India. This is due partly to the prevention of anopheline breeding in irrigation channels, and partly to the lowering of the subsoil water and consequent reduction in relative humidity.

(d) The Training of Streams.—Some of the most dangerous anophelines breed in the grassy margins of streams or in pools in connection with streams. Much good can be done by straightening out the bed of the stream, draining pools into it, and clearing away the vegetation along the edges.

(iii) Larvicides.—The number of substances which have

been employed to destroy mosquito larvæ is very large indeed, and only the most important ones can be considered here. These are (*a*) oil, and (*b*) paris green.

(*a*) *Oil.*—The most generally successful form is a mixture of crude oil with kerosene in varying proportions, depending on local conditions. Thus, if vegetation is present a thinner oil is required, whilst if the temperature is very high a thicker form must be used. In very hot climates crude oil may be used alone, or with the addition of a small percentage of a vegetable oil, such as castor oil, which greatly increases the spreading power. A little cresol added increases the persistence of the film.

Oil may be applied by spraying it on the surface of the water, or by soaking gunny bags, lumps of tow or cotton waste in it and throwing them into the water. It has the advantage of killing both anopheline and culicine larvæ, and it is easy to see where it has been applied ; but it spoils water for domestic purposes, kills fish, and is likely to be stolen by unscrupulous employees. Moreover, vegetation has first to be removed to render it fully effective.

(*b*) *Paris green*, or copper aceto-arsenite, comes nearer to fulfilling the requirements necessary for a perfect larvicide than any other chemical at present available. It is highly toxic to anopheline larvæ, does not kill fish or spoil water for domestic purposes, is effective even in the presence of dense vegetation and is useless for any other purpose, and hence not likely to be stolen. In addition it is much more quickly applied and considerably less expensive than oil. On the other hand it has the disadvantage that it has no effect on the eggs or pupæ of mosquitoes, and that it does not destroy culicine larvæ ; also, its use requires supervision by some responsible person.

Paris green should be of a deep green colour, should contain at least 50 per cent. arsenious oxide, its solubility in water should not exceed 3 per cent., and it should be capable of being passed through 200, or better 300 mesh, bolting cloth. In addition, each batch should pass a practical field test before being accepted.

Various diluents have been used with it, road dust, slaked lime, soapstone, china clay, sawdust, "red earth," french chalk, spoilt flour, etc. For use in small streams, drains and irrigation channels a dilution of 1 in 100 is sufficient, but when it is desired to blow a cloud of dust over large areas of swamp or sheets of water it is better to use it in a strength of 5 per cent. In the latter case a light diluent such as slaked lime or powdered soapstone is usually the best. Road dust varies in composition in every locality, and if there is a large proportion of sand in it then it cannot be used effectively for dusting large areas.

Whatever diluent is used, mixing must be thorough, and

for this a specially made apparatus is required. It is usually necessary also to pass the diluent through a sieve of 50 mesh wire gauze before mixing. The mixture may be applied by hand, or by various forms of blower, the most effective being the rotary type, which is now obtainable from many firms in India and elsewhere.

In America and in some places in Italy large swamps have been treated by distributing paris green from aeroplanes, with excellent results.

(*iv*) *Larvicidal Fish.*—The use of larva-eating fish as a means of malarial control has been practised in Bombay for the last 30 years. There are several species of fish in India which prey on mosquito larvæ, notably those belonging to the genera *Haplochilus*, *Anabas*, *Barbus*, *Trichogaster* and *Badis*. *Anabas scandens* (Koi or Khajura) and *Haplochilus lineatus* (Piku) are the two species used in Bombay. *Gambusia*, or top-minnows, which have a great reputation as larvicidal fish in America and in Southern Europe have recently been introduced into India. They have been successfully acclimatised in many places, and on account of their small size, rapid proliferation, and adaptibility to extremes of climate, they are probably more suitable for larvicidal purposes than any other species.

There are certain disadvantages in the use of fish in malaria control, the chief of these being as follows :—

(*a*) Fish are only of value when present in sufficient numbers.

(*b*) They are only completely effective in the absence of vegetation and floating debris.

(*c*) Over-zealous persons are apt to introduce larger species of fish which prey on them.

(*d*) Unless sufficient food is present they eat their own progeny, so that wells, etc., have to be re-stocked periodically.

(*e*) Their use necessitates the employment of special staff to look after the fish and to keep the breeding places free from weeds and debris.

(*f*) Small boys can be relied upon to catch them if they get the opportunity.

For these reasons the use of larvicidal fish in India is rarely to be recommended except when for some reason it is found impossible to employ any other method of malaria control.

D. The use of Drugs

The value of the cinchona alkaloids, particularly quinine, in the treatment of malaria, has been known for many years. Quinine may be used either for prophylaxis, *i.e.*, for the prevention of infection, or for treatment. As regards prevention of infection, there is no evidence that the use of this drug is of any effect. But the term "prophylaxis" in relation to malaria is frequently employed to mean the prevention of

clinical symptoms following infection, and for this purpose it undoubtedly has its uses. Quinine prophylaxis in this sense has proved of great benefit in the case of prisoners in jails and when given to troops serving in malarious countries, and it has been found that the systematic quininisation of school children greatly reduces the spleen rate. In the case of a threatened epidemic of malaria the prophylactic use of quinine will save many lives, whilst in any malarious community it will have good effect by reducing the number of human carriers of benign tertian malaria, though it has no effect on the gametocytes of malignant tertian (crescents). It is particularly necessary that the quinine should be administered to the children, who, as we have seen, form the principal reservoir of the disease.

The most effective dose to be given for prophylactic purposes is probably 10 grains daily, but it is seldom possible to do this and it is more usual to give 10-15 grains twice weekly. The drug is best administered in solution, but it is frequently impossible to give it in this way on a large scale. If tablets are used, the best form of the salt is the bihydrochloride. The tablets should be freshly made, and their solubility tested before use.

It will be readily understood how difficult it is to induce an uneducated village population to undergo this treatment. It is usually vigorously opposed by the local "quacks," who not infrequently spread a rumour that the Government officials are trying to wipe out the population by poisoning them. But at least every effort should be made to make a sufficient supply of the drug available at as low a cost as possible, in places where malaria is rife.

Recently various synthetic drugs have been introduced, the best known being Plasmoquin (or Plasmochin) and Atebrin. Plasmoquin has a specific action on the gametocytes (crescents) of the malignant tertian parasite, and in India it has been used along with quinine to reduce the relapse rate in benign tertian malaria. Unfortunately, in some cases dangerous toxic symptoms are produced, so that it can only be used with safety if the patient is under strict observation. Atebrin has no effect on crescents, but has a marked action on the asexual forms of all malaria parasites. Up to the present time it cannot be said that any of the synthetic drugs is likely to replace quinine. They may be looked upon as useful adjuvants to quinine in the campaign against malaria. It is to be hoped that future research may produce a drug which is less toxic, more rapid in its action, and very much cheaper in price. Such a drug would provide a powerful weapon not only for treatment, but also for the prevention of malaria.

E. Improvement of Economic Conditions

It has been shown above how famine, poverty and overcrowding are important predisposing causes of malaria.

Conversely, any measures which bring about an improvement in economic conditions will aid in the prevention of malaria and other diseases. On these considerations is based the policy of agricultural improvement in Italy known as *bonificazione*. James considers that the disappearance of malaria in England is mainly due to the improvement in the economic condition of the people, combined with advances in general sanitation and medical treatment, and points out that the disease has disappeared in spite of the fact that *A. maculipennis*, an efficient malaria carrier, continues to exist there in large numbers. In India the principal measure of this kind consists of carefully planned irrigation projects, accompanied by adequate schemes of drainage, and regulations prohibiting the cultivation of wet crops in the immediate vicinity of towns and villages, and the proper care of irrigation channels.

Recommendations regarding the control of malaria in villages will be found under the heading "Village Sanitation."

Malaria Forecasts.—Lieut.-Col. C. A. Gill, I.M.S., has made an important advance by the introduction in the Punjab of malaria forecasts, based on a consideration of the meteorological and economic factors affecting the spread of the disease together with the evidence regarding the amount of communal immunity in different localities derived from the spleen rate. For several years these forecasts have been prepared, and have turned out to be remarkably accurate. Given such an accurate forecast, it is possible to mobilise personnel in the danger areas in advance, and to undertake preventive measures before the commencement of an outbreak of malaria.

KALA-AZAR

Manson describes kala-azar as an infective disease characterised by chronicity, irregular fever, enlargement of the spleen and often of the liver, the presence of the "Leishman body" in these and other organs, emaciation, anæmia, frequently a peculiar hyper-pigmentation of the skin, and a high mortality.

Under the name of *Burdwan fever* the disease was known in Lower Bengal in the early fifties of the last century, and it was known to exist in Assam from as far back as 1869. In 1881 it broke out in an epidemic form at the foot of the hills just to the east of the Brahmaputra. The earliest record of the disease is by Clarke who in the Assam Sanitary Report for 1882 described it as a severe form of malarial cachexia.

Etiology.—In 1903 Sir William Leishman first described the parasite of kala-azar, and about the same time Donovan observed similar bodies in the spleen of patients dying of chronic fever in Madras. These parasites have been named after them and are known as "Leishman-Donovan bodies." They are small round or oval bodies measuring 2 to 4 μ in

diameter. In each parasite an oval macro- and a rod-shaped micro-nucleus and a capsule can be differentiated. The parasites are almost invariably intracellular, where they grow and multiply. The distribution of the parasites in the body is general, but they are most numerous in the spleen, the bone-marrow and the liver. They also occur in the blood though in small numbers, being found there both in polymorpho-nuclear and mono-nuclear leucocytes. In the blood they are found in great abundance towards the termination of the case, especially during fever, and when intestinal symptoms are present (Donovan). Rogers demonstrated the flagellate stage of the parasite by cultivating it *in vitro*.

Both sexes and all ages are equally affected and no occupation is a bar to the disease. The majority of cases occur during the cold season.

The disease is very common in Calcutta, and seems to attack all classes. It is not so common, however, in the upper-class Europeans.

Mode of Transmission.—This is still doubtful. The fact of several cases occurring in the same family or house suggests mode of transmission through animals or insects domestic in their habits.

Notwithstanding a large amount of work the mode of infection is still uncertain. Patton suggested the bed-bug theory. Others seem to believe that the parasite may leave the human body either by the alimentary canal or through the agency of blood-sucking insects. Of the different possible blood-sucking insects mosquitoes, lice, fleas and ticks may be excluded on various epidemiological and experimental grounds. The sandfly has been strongly suspected of transmitting the disease; and a large amount of work has been done within recent years in attempts to incriminate this insect. Knowles, Napier and Smith have shown that when *Phlebotomus argentipes*, a common sandfly of Calcutta, was fed on the blood of a kala-azar patient there was remarkable development of the flagellate forms in the mid-gut of the insect. In some insects these reached the mouth parts, so that it was possible for them to enter the blood of the victim when bitten by these flies. Patton and Hindle have since been able to obtain similar development in *P. major* and *P. sergenti*. The actual transmission of the disease to man under experimental conditions still remains to be done. The possibility of the infection being carried *via* the alimentary canal has been brought forward by Shortt who infected hamsters by oral administration of saline emulsions of infected livers and spleens, and by cultures of *L. donovani* given orally. The same worker has more recently succeeded in infecting hamsters by the bite of *P. argentipes*, but all attempts to transmit the disease from man to man have hitherto been unsuccessful.

Prevention.—The introduction of the treatment by antimony preparations has robbed the disease of much of its terrors by reducing the number of persons harbouring the infection. The disease is essentially a house infection and repeated number of cases occur in the same house. The infected houses or localities should as far as possible be avoided for permanent residence. This measure alone proved effective in dealing with outbreaks in certain districts.

Trypanosomiasis

Sleeping Sickness

It is a chronic disease found in tropical Africa, produced by protozoal parasites, *Trypanosoma gambiense* and *T. rhodesiense*, and transmitted by the tsetse fly. It occurs only in those parts of Africa where the fly is found.

Etiology.—All persons of all ages are susceptible to this infection provided opportunity occurs for the infected tsetse fly to bite. Two varieties of the parasite cause the disease in man, each type being responsible for a distinct type of ailment. The parasite is found in the fresh blood of an infected person, but the number present varies. Sometimes it is difficult to find a single parasite in the slide. During febrile attacks it is found in large numbers. It is also found in the lymphatic glands and in the later stage in the cerebrospinal fluid.

Mode of Transmission.—This may be (1) cyclical, and (2) mechanical.

(1) *Cyclical.*—When the tsetse fly bites an infected person it draws with the blood some parasites which undergo developmental changes in the midgut (*see* page 372). During this stage the fly cannot infect but becomes infective after about twenty days, when the parasites appear in the salivary glands, and remain infective during the several months of its existence.

(2) *Mechanical Transmission.*—Duke working in the Mwanza area of Tanganyika Territory has pointed out that direct transmission by the fly from one patient to another is possible without the parasite going through the elaborate cyclical development within the insect. This direct transmission has been proved in the case of animal reservoir hosts. Until recently it was believed that the fly became infected from man only, but it is now generally held that big game and antelopes are commonly infected and form reservoirs for the virus of the disease.

Although both *G. palpalis* and *G. morsitans* can be infected experimentally with both forms of human trypanosomes, in nature *G. palpalis* is the carrier of *T. gambiense* and *G. morsitans* of *T. rhodesiense*.

The *incubation period* is indefinite, but it is generally believed to be from 2 to 3 weeks, it may be several months before any symptoms could be detected. The disease is insidious in its onset, characterised by irregular attacks of fever lasting for a week and then disappearing to reappear again after an interval. In some cases the fever may be continuous but is always irregular. The glands of the neck and other parts of the body become enlarged and tender. The real *sleeping* part of the disease comes on in the later stage. In fact it is the terminal manifestation and depends upon the implication of the nervous system either by the parasite or its toxin.

Prevention.—This depends on the avoidance, as far as possible, of being bitten by the flies. The fly area should be avoided. The fly bites during the day, therefore, the journey through the fly area should be done during the night. Infected persons should be spotted out and isolated and properly treated with Bayer 205 and tryparsamide, to free the peripheral blood of the parasite. An early case requires seven weekly injections of Bayer and seven of tryparsamide. The fly prefers dark coloured garments, therefore white dress should be worn.

Spread of the disease should be controlled by declaring main endemic centres "infected areas". Here labour recruiting should not be allowed except under medical supervision, and no enterprises entailing employment of labour should be allowed unless an adequate medical staff is available. Provision should be made for compulsory treatment of patients.

In Belgian and French territory in Africa the disease is being controlled by the general application of the medical passport system, which involves the medical examination of all persons moving from their own locality. The disease is being gradually diminished in the most heavily infected areas by the repeated examination of the whole population, with treatment of cases with organised brigades. In Tanganyika the problem is exceedingly serious, the large portion of the territory being infested with *G. morsitans* and *G. swynnertoni* and owing to the existence of endemic and epidemic foci of *T. rhodesiense* infection carried by these species. Control is being effected by concentrating scattered hamlets into cleared settlements and by improved methods of agriculture. Here also movement of population in infected areas is controlled by a permit system. In Soudan a well-organised and fully staffed campaign has practically eradicated the disease from two infected provinces of Mongalla and Bahr el Ghazal. Isolation of patients in treatment camps, removal of villages from fly infested areas, and control of movements of inhabitants and emigrants are the measures adopted.*

* W. B. Johnson, *Tropical Diseases Bulletin, May, 1931.*

Yellow Fever

Definition.—It is an acute fever characterised by jaundice and albuminuria, occurring endemically in certain geographical areas. It is caused by a special filtrable virus of unknown morphology, and is carried from man to man by stegomyia mosquitoes, *Aedes ægypti* or *Aedes argenteus*, which cause dengue fever in India.

Distribution.—The most characteristic feature about this disease is that it is restricted to certain geographical areas. It is possible that it spread from tropical America through Mexico to tropical and sub-tropical countries on either side of the Atlantic Ocean. It is a disease of the sea-ports and is endemic in certain areas of the West Coast of Africa and of the South and Central America—particularly the Panama Canal Zone. Epidemics occurred at different times within the last ten years in Southern Nigeria, Gold Coast Colony, Gambia, Sierra Leone and from Senegal to Congo. No case has been recorded from India and the Far East.

Epidemiology.—The virus can be transported from one place to another but for its development in an epidemic form it requires a mean atmospheric temperature of over 75° F. Below this point it ceases to grow. Since dampness favours the disease, it is seen mostly during the rainy season. Carter has pointed out that the disease rarely spreads more than 75 yards from an infected place and ships moored at a distance of 400 yards from an infected area are safe. Infected houses are dangerous as there may be infected mosquitoes. The *fomites* play no part in the spread of the disease.

The absence of the disease in India is due to the absence of the virus, possibly due to the length of voyage from the infected countries to India, although the carrier stegomyia mosquitoes are quite common in India. With the opening of the Panama Canal and the introduction of air travel it has become possible for persons to land in India while incubating infection contracted in an infected country. There is also the possible contingency of accidental carriage in air craft of infected mosquitoes, or such uninfected ones as are capable of becoming vectors of infection if planted in a territory ordinarily unfrequented by them, but perchance containing the infective material of this disease. If the disease spreads to East Africa the danger to India will be great.

Immunity.—One attack often confers immunity for a long time, although a second attack within two years is not uncommon, but the attack is as a rule mild. People who live in endemic areas often show some degree of immunity. The incubation period is generally 4-5 days, rarely exceeds 13 days. Although the period elapsing between the introduction of the virus and the first appearance of the fever is usually 3-5 days, yet it requires at least 12 days before that

virus after removal from one person can be effectively implanted into another person. The lapse of time subsequent to the injection of infected blood by a stegomyia before it can be infective is generally 12-19 days, but this varies depending upon temperature. Once infected the mosquito will remain infective for the rest of its life.

The Virus.—Noguchi thought that the causative factor of the disease was a spirochæte, *Leptospira icteroides*, but subsequent observers did not substantiate his finding. It has been definitely proved that the virus is ultra-microscopic though filtrable, and can be passed through a Berkefeld filter. It is however not filtrable when developing in the mosquito. There is no evidence to support the view of Noguchi and the true morphology of the virus of yellow fever is still unknown.

Prevention.—The most effective prevention depends upon active measures taken for mosquito control, specially the stegomyia mosquito. Before any anti-mosquito measure is adopted a careful survey of the habits and distribution of the local species should be made and all patients suffering from the disease isolated in mosquito proof rooms. The disease has been banished from Havana and Panama Canal Zone by the active measures taken against breeding and spread of mosquitoes and protecting the sick against the bites of these insects. In any campaign against the disease the ideal to be aimed at is the extermination of the mosquito by all the known anti-mosquito measures. The stegomyia being a domestic insect every effort should be made to prevent its breeding in and around the house. All water tanks, cisterns, vessels where water can collect should be suitably protected by proper screening or other means. Ships should not be allowed within four-hundred yards of an infected port and any mosquito found in the steamer should be destroyed. All infected houses should be fumigated and every one living in the infected areas should use mosquito nets.

Effort should be made for proper sanitary control of air craft and disinsectisation with HCN or other fumigation of air craft and cargo prior to departure from the infected country.

Protective Inoculation.—Convalescent serum of those who have recovered from recent illness has been found to give some protection. Hindle has shown that a dead virus preparation made from the liver and spleen of monkeys killed when moribund from the disease, given to susceptible animals produced a high degree of immunity. Subsequently Findlay and Hindle pointed out that the passive immunity produced by the use of convalescent serum disappears within a short time (one to two weeks) and may avert an illness, but it has little effect on the symptoms already appeared. They have shown that a subcutaneous or intraperitoneal inoculation of a mixture of the virus and the specific serum produces a more durable immunity than that conferred by the serum alone.

White mice are susceptible to the virus of yellow fever. In these animals it produces an encephalitis and the virus becomes 'fixed' in strength. Human serum from recovered cases of yellow fever mixed with such fixed virus and injected into white mice will protect the animal from the development of the disease. Such protection is also given by human serum from persons who may not have had the disease clinically. Persons giving such 'protection' with the white mice test are considered to have had a mild infection of yellow fever. Areas in which a large number of such persons exist giving the protection tests are considered to be 'endemic areas' even though no obvious disease occurs. They are also called 'silent areas' of yellow fever. This 'protection test' has been carried out on a large scale in Equatorial Africa and the endemic areas have been found to be much more extensive than hitherto thought.

The International Sanitary Convention makes certain provisions to prevent the carriage of infection of yellow fever from infected localities to uninfected areas. The measures to be taken at infected ports by the signatories of the Convention include the prevention of embarkation of persons showing symptoms of yellow fever, and the prevention of mosquitoes gaining access to ships. Ships have been classified as infected, suspected and healthy and the measures to be adopted for infected ships have been given in detail.

While there is probably little likelihood of yellow fever being brought to India by shipping, owing to the length of time that voyages from endemic areas take, the development of aeroplane traffic has altered the situation. Yellow fever patients are infectious to mosquitoes only during the first three days of illness, while the Aedes mosquito does not become infectious until twelve days after the biting. Recently a special International Air Convention (*see* page 11) has been agreed on by which signatory countries where yellow fever is endemic have to establish Anti-amaryl Aerodromes, while countries fearing the introduction of yellow fever like India in addition to taking ordinary precautions, may if they think fit under exceptional circumstances, prohibit the entry of aeroplanes from endemic countries.

Relapsing Fever

Definition.—An acute fever of sudden onset, characterised by periodical attacks of relapses at intervals of seven or more days. It is caused by a spirochæte and carried by either louse or tick.

As early as 1876 Vandyke Carter detected the spirochæte in some Indian patients in Bombay and was able to convey the disease to men and monkeys by injecting infected blood. Mackie in India showed that body louse was the vector of

this disease, while Dutton pointed out that tick can also convey the disease by its bite. It has been further shown that louse relapsing fever cannot be conveyed simply by the bite of the infected louse, but the spirochæte enters the body after it is released by the crushing of the louse into the puncture or into the abrasion caused by scratching (*see* page 385). Nicolle and Anderson were able to infect animals with spirochætes of tick relapsing fever through the intermediaries of lice.

Since it is essential that the disease should be conveyed by the bite of lice or ticks, it cannot spread in the absence of these insects, and have practically disappeared in cleanly civilised communities. It is found in Central Africa, East Africa, Uganda and Madagascar. It is common in Persia and epidemics have been known to occur in India extending over a large area with the exception of Bengal, Assam and part of Orissa. Indian relapsing fever is lice borne.

Etiology.—The different types of relapsing fever are caused by a spirochæte, known as *Treponema* (*Spirochæta*) *recurrentis*. It is gram negative and stains with most dyes. The parasite occurs in the blood during the febrile stage and disappears with the subsidence of temperature and is absent from the blood during the afebrile stage, although the blood remains infective to animals. The parasite is also found in the lymph and cerebrospinal fluid of the patients. Once the parasite enters the insect vector it takes about 5-16 days to develop when the insect becomes infective, and remains so for the rest of its life. Asiatic relapsing fever is due to *T.carteri* ; American relapsing fever to *T.novyi* ; North African relapsing fever to *T. berberum* ; Central African relapsing fever (Tick fever) to *T.duttoni*.

Epidemiology.—Like typhus fever louse relapsing fever is found when the economic condition of the people is bad and therefore affects the class of people who live under bad hygienic conditions, and is therefore known in Ireland as "Famine fever". In India the lice die off during the hot months and the disease automatically disappears. The tick relapsing fever on the other hand shows no definite seasonal incidence, is confined to certain areas, and is more a house disease. Unlike lice which are carried from place to place by human travel, ticks remain confined to one locality and lurk in walls, floors, on the grounds, etc., instead of on the bodies of human beings. The spirochæte may penetrate the ova of the tick and therefore the offsprings of the ticks are infective for two generations and the infection can be transmitted hereditarily.

Prevention.—Relapsing fever is primarily a vermin disease and therefore it should automatically disappear when the people realise that personal vermin are a nuisance and a menace to health. The first principle involved in the

prevention of louse relapsing fever is personal cleanliness so that the body cannot harbour lice. The patient should be deloused and isolated. Nurses, doctors and attendants should use louse proof clothes and should have their clothes sterilised after visiting such patients. They should cleanse themselves with some germicidal soap. A regular campaign aginst lice should be undertaken in infected areas. Owing to the more elusive character of the ticks it takes a longer time to deal with tick borne disease. Steps should be taken to avoid bites by ticks by avoiding houses known to be infested with these insects. Sleeping on the ground is dangerous, and should be eschewed. The use of mosquito net is essential. Night lights scare away ticks. The infected houses should be fumigated with hydrocyanic acid gas whenever possible.

TYPHUS FEVER

Under this are included the following types of fever, (*a*) *Louse Typhus*, carried by lice, viz. endemic typhus, jail fever, etc.; (*b*) *Flea Typhus*, carried by rat-fleas, viz. Brill's disease; (*c*) *Tick Typhus*, carried by ticks, viz. Rocky Mountain fever, Indian tick typhus; (*d*) *Mite Typhus*, carried by mites, viz. Japanese River fever, Tsutsugamashi or Kedani fever; (*e*) Typhus due to unknown vector. From the point of view of clinical manifestations all these different types show a resemblance to one another.

Epidemiology.—Louse typhus is a disease of the cold and sub-tropical countries. Though not so common in the tropics it is not unknown, as the rash is often difficult to detect in coloured skin. It occurs in endemic form in North-Western Frontier Province and in some districts of Punjab. As pointed out by Megaw the typhus in India is carried by ticks. As a rule louse typhus occurs when the conditions of living are low, and epidemic outbreaks occurred during and after the war in Russia, South East Europe and Germany. Tick typhus closely resembles Rocky Mountain Fever, and some consider both the diseases to be the same. The best known infected localities in India are Bhim Tal and Sat Tal on the wooded borders of small lakes at an altitude of about 4,500 feet in the Himalayas. It occurs in the summer and autumn in the hills, while in the plains it is observed during the cold season. As a rule Europeans are mostly affected who go to those places for shooting. Of the indigenous population only children are affected (Megaw). Japanese River Fever is common along the banks of certain rivers in Japan and occurs in many other places in the Far East. Similar types of diseases have been reported from Philippines, Malaya and Indo-China. It is carried by the bites of certain mites, chiefly *Trombicula akamushi*. It affects chiefly men who work in regions where the vector mite is common, although women and children are equally liable.

Etiology.—The virus possibly responsible for all the varieties of fever is believed to be *Rickettsia prowazeki*. It is present in the blood plasma of infected persons during the first five days of the disease. It is possible that it goes through developmental changes within the louse which becomes infective from the fourth to the seventh day after a meal of typhus blood. Once the louse becomes infected it remains infective for the rest of its life.

Preventive measures are practically the same as discussed under relapsing fever. The lice pass from the sick to the healthy, or through clothes, beddings, etc., which have been in contact with those infected. Over-crowding in dark and ill-ventilated rooms greatly favour the dissemination of infection. Every effort should be made to delouse the patient. The clothes and garments should be sterilised and the contents of the living room subjected to thorough disinfection.

PLAGUE

Plague is an acute infectious disease caused by a specific bacillus and characterised by inflammation of the lymphatic glands, sometimes by pneumonia or septicæmia.

The first authentic account of plague refers to the latter half of the sixth century A. D., when it lasted for fifty to sixty years and was known as the plague of Justinian. From that time there was no other epidemic till the Black Death of the fourteenth century. In the fifteenth century there were outbreaks in many parts of Europe, chiefly imported from the East. The first outbreak of plague recorded in India was in 1612 by the Emperor Jahangir. In 1815 bubonic plague broke out in Kutch, and then spread to Sind and Guzerat, and lasted till 1821. In 1823 it broke out in the Kumaon Hills on the west of Nepal, and was known as *Mahamari*. In 1836 a fresh outbreak occurred in the town of Pali in Rajputana, spreading to Jodhpur and Marwar, and continued till 1838. This was known as the Pali plague.

In 1871 plague appeared in an endemic form in the south west of China in the province of Yunan, and, probably following the trade route, it spread to Pakoi on the Gulf of Tonquin. In 1894 it extended to Canton, and then appeared in Hong-Kong and many other places in the southern provinces of the Chinese Empire.

In 1896 it broke out in Bombay, having probably been imported from Hong-Kong, and thence it spread to Calcutta, and subsequently throughout India. The total number of deaths recorded from this cause in India for thirteen years (1897-1909) amounted to 6,133,476. In 1918-19 the mortality from plague in India sank to less than one-sixth of the mean mortality during the past twenty years.

The Bacillus.—The plague bacillus, *Pasteurella pestis*

was first discovered by Yersin and Kitasato during the Hong-Kong outbreak in 1894. It is a short oval bacillus with rounded or square-cut ends occurring singly or in dumb-bells, and occasionally in chains; it is non-motile and does not form spores. The bacilli are demonstrated from postmortem specimens or from puncture of infected glands.

The bacillus is killed by heat, and an exposure for an hour at 58° C. is fatal. On the other hand it has remarkable power against cold and loses its virulence on drying. It is readily destroyed by antiseptics, a 1 in 1000 corrosive sublimate or 1 in 100 chloride of lime solution being efficient. It grows readily in broth specially if a layer of *ghee* floats on the surface. The German Plague Commission stated that the longest time the bacilli of infected materials remained active was eight days. They further showed that the *B. pestis* multiplied up to 45 days in the gut of the flea. In drinking water they die in three days, and in sterile water in eight days. Direct sunlight kills the organisms in three to four hours.

It is also present in great abundance in the spleen, intestines, lungs, kidneys, liver. and other viscera, and also, though in small numbers, in the blood. In the pneumonic type it is present in the sputum in enormous numbers.

The *Bacillus pestis* has not been recovered from the mud or cowdung floors in India. The Plague Commission has shown that floors of cowdung if contaminated with *Bacillus pestis* do not remain very infective for more than forty-eight hours, and that floors of *chunam* cease to be infective in twenty-four hours.

In addition to man, the monkey, cat, rat, mouse, guinea-pig and rabbit are also susceptible to inoculation.

Modes of Entry.—The bacillus is transmitted from rat to man, rat to rat, man to rat and from man to man, by one of the following ways:

1. *Infection through the Fore Intestine.*—A flea if interrupted during a feed may infect at its next feed, after a short interval, either by depositing the bacilli through contaminated mouth parts or by regurgitation of the contents of the œsophagus or midgut. The Indian Plague Commission do not support these theories and hold that regurgitation from the mid gut is impossible owing to the proventricular valve.

2. *Infection by the Hind Intestine*:—Fleas may expell the bacilli during a bite with the fæces and thus cause infection either through scratching or through any existing abrasion. This view is not accepted now. Martin and Bacot, however, found that the plague bacillus lost its virulence in the stomach of the flea and that the fæces contained few bacilli.

3. *Direct Infection by a Blocked Flea.*—This is the most common mode of entry. Martin and Bacot have shown

that after ingesting plague infected blood the proventriculus of the flea gets blocked with a mass of *B. pestis* growing on the ingested blood. The frantic efforts of the thirsty flea to suck more blood causes the injection of the bacilli into the skin of host. It may leave one host and pass to another. Since the blocking may not be complete, the proventriculus does not act as a valve. A partially blocked flea draws blood from the host and also some of the contents from the gut. A partially blocked flea therefore is a serious danger to the community, and it lives longer than a completely blocked flea.

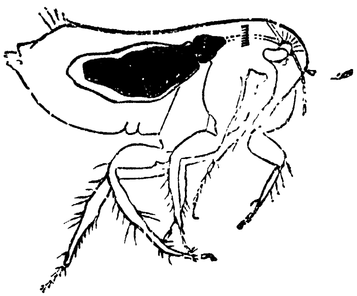

FIG. 147.—Flea viewed as a transparent object. The proventriculus and stomach contain a mass of plague culture (Manson).

4. *Double Bite Method of a Blocked Flea.*—Hirst has shown that a blocked flea feeding on an infected rat fills the fore-intestine with the infected blood as it is prevented from passing into the mid-intestine, which is already blocked. During the second feed the wound becomes infected with the bacilli from the blood of the first rat. This double bite method is possible with human beings dying from septicæmic plague.

Pneumonic plague enters the system through inhalation by droplet infection.

The fleas infect man after the rats die of plague. They leave the cold body of the dead rats and bite man for want of a more susceptible victim. As a rule they bite the bare feet or legs thus causing the buboes to appear in the inguinal region. On the other hand sweepers who handle dead rats get beaten on the hands and arms and develop axillary buboes.

Kitasato has demonstrated the presence of *Bacillus pestis* in the dust from the walls of a room occupied by a plague patient. This mode of infection is not common in India, though the plague infected houses are generally ill-ventilated, dark, and densely crowded.

Means of Spread.—The conclusions of the Indian Plague Commission may be quoted *in extenso* :—

1. Pneumonic plague is highly contagious. It is, however, rare (less than 3 per cent. of all cases) and plays a very small part in the general spread of the disease.

2. Bubonic plague in man is entirely dependent on the disease of the rat.

3. The infection is conveyed from rat to rat and from rat to man solely by means of the rat-flea.

4. A case of bubonic plague in man is not in itself infectious.

5. A large majority of plague cases occur singly in houses; when more than one case occurs in a house the attacks are generally nearly simultaneous.

6. Plague is usually conveyed from place to place by imported rat-fleas which are carried by people on their persons or their baggage. The human agent himself not infrequently escapes infection.

7. Insanitary conditions have no relation to the occurrence of plague except in so far that they favour infestation by rats.

8. The non-epidemic season is bridged over by acute plague in the rat, accompanied by a few cases amongst human beings.

The Commission has further shown that an epizootic of rat plague may start without contact or even proximity of healthy and infected animals. As long as fleas from an infected animal are transferred on to a healthy animal they will cause infection. The chief agents in the development and perpetuation of plague epidemics are the rats and the rat-fleas (*Xenopsylla cheopis*) and other species of fleas, such as *Ctenocephalus canis*, which also bite dog, rat and man.

Recent researches have demonstrated that the rat-flea can be transferred through grain and in grain sacks. This fact was responsible for cases of plague in ships which were free from rats but were carrying grain from Basra to Amara and Bagdad during the last War.

Owing to the free discharge of the organism with the sputum and the consequent direct infectivity of the disease at short ranges, *pneumonic plague* spreads from man to man directly by droplet infection, but fortunately this variety of plague is rare. It occurs occasionally in cold climates like that of Eastern Siberia and Manchuria. Pneumonic plague is more liable to occur in temperate and cool seasons. As it does not lead to an infection of other animals or to an epizootic, the epidemic has a tendency to die out rapidly.

The Rat.—Although epidemics of pneumonic plague may occur without the intervention of rats, it is definitely proved that in epidemics of bubonic plague the rat plays an important part in the propagation of the disease.

The disease is essentially a rat disease and is carried to human beings by fleas which have fed on infected rats. The rats chiefly responsible are the black domestic rat (*Rattus rattus*) and the brown rat, *Rattus norvegicus* (*decumanus*), which is the common water rat or sewer rat. *R. rattus* is most susceptible to plague, and being a domestic rat is found in close connection with man. *R. norvegicus* is a wild rat. These rats are usually infected with fleas, chiefly *X. cheopis*, *X. astia*, *X. braziliensis* and *Ceratophyllus fasciatus*. (*See* page 377).

Rattus rattus, is the common domestic animal in India, and lives and breeds in and about human dwellings. It is the black rat and feeds upon grain and other articles of food stored in the house. It is distinguished from *Rattus norvegicus*, the brown rat, by its tail being longer than the body and its large ears. It has a small and pointed head, a smooth coat, and is comparatively small. The black rat does not migrate to any distance. When the infection is present and the rat population sufficiently numerous to maintain an epidemic, an epizootic (or precedent outbreak of the disease in animals) takes place. If the rat population is scanty, the epidemic either cannot arise or is of short duration. The epizootic among rats is followed after about a fortnight by the outbreak of human plague.

The plague infected flea may live apart from the rat host, and remain infected for a period of 23 days, and in low temperature even longer. In hot dry climate, say 80°F. the infected fleas die rapidly, the probable cause of cessation of plague in the hot season. In certain parts of India the climatic conditions are such that given a sufficient quantity of black rats to maintain the infection, the disease may persist throughout these months which in other parts of the country are non-epidemic. Moreover, in any part of India, plague may persist among rats through the non-epidemic season without revealing its presence by unusual sickness and mortality ; this period is known as the "carry over season." The treatment of carrying-over village is therefore of utmost importance in the prevention of plague. In the Punjab plague is essentially a rural disease.

The following method of treating carrying-over villages was devised by Colonel (now Major-General) Forster, when he was the Director of Public Health of the Punjab. A list of carrying-over villages was first made as follows :—

(*a*) Those in which plague has been endemic for the last 3 or 4 years.

(*b*) Those in which plague was present in the month of June.

(*c*) Those which have been infected with plague after April.

The scheme aimed at by treating these villages by deratisation three times during the period from May to November, which include the off season : say once in May, once in August, and once in November. The following figures are striking by showing the results of such operations. Where three operations were given, plague recrudesced in the next year in 1 p.c. of the villages ; where two operations were given plague recrudesced in 2 p.c. of the villages ; where one operation was only given plague recrudesced in 5 p.c., where no operation was done at all. the recrudescence was between 50 and 60 p.c. The village was first visited by the preparatory gang who selected the houses to be deratised.

The operation was carried out with "cyanogas" which is a brown powder evolving hydrocyanic acid when it comes in contact with moisture and contains 50 p.c. calcium cyanide. The operation is, therefore, dangerous and requires evacuation of the houses to be treated for at least 12 hours. They are then prepared for treatment by plugging up as many of the rat holes as possible with mud or clay both inside and outside the house so that the rats might not escape. Next day the deratising gang arrived and proceeded to treat each house by means of pumping in cyanogen gas into the rat holes with a hand pump (*see* page 436), the plugs from the rat holes being removed one by one and replaced. The powder was also scattered amongst the walls and the roofs of the houses. Next day the clearing up gang arrived and examined the results of treatment by digging up some of the rat holes. At the same time the villagers were instructed in anti-rat methods, *e.g.* by keeping the food protected by placing it on top of a platform placed on a long smooth wooden pole. In large municipalities also rat killing by either trapping or any other method is usually the method of choice for anti-plague work. The rat population approximates to the number of human population in towns and it has been estimated that if one rat per head per annum is killed then human plague is unlikely to appear in the town.

The prevalence of rat-fleas is intimately associated with the season of the year. They freely multiply and are very active when the temperature is 50°F. or thereabout. The average life of the flea apart from its host has been found to be about ten days in Mesopotamia, while in a tropical temperature it can harbour the bacillus when feeding on blood for forty-five days.

In Manchuria the tarabagan flea (*Ceratophyllus silantievi*) plays the chief part in spreading the disease. Apart from the rat, certain species of marmot called "tarabagan" are responsible for Mongolian and Siberian epidemics of pneumonic plague. They harbour the bacillus in their body and constitute more or less a permanent reservoir of the plague bacillus, the infection being conveyed through fleas which infest these animals. It is however now believed that these fleas play a less important part and that infection is transmissible *via* the alimentary canal. The pouched marmot of the Caucasus, and ground-squirrel of California are also important reservoirs of *B. pestis.*

Seasonal Prevalence.—Season has an influence on the epidemicity of plague depending on the temperature and humidity. R. St. John Brooks has pointed out that in addition to high temperature a dry atmosphere as indicated by high saturation deficiency, is an important factor in reducing plague (*see* rat-flea, page 377). This view has been confirmed by Rogers, who holds that the decline of plague in India

during the height of the monsoon season is due to high temperature and high saturation deficiency. Thus the increase of plague in Bombay, Deccan and Central Provinces during the monsoon is attributed to the comparatively low temperature which occurs in that season, as compared to North Western India where there is no appreciable increase till the months of November and December. By a study of the climatic conditions Rogers was able to make more or less accurate forecasts of the probable rise and fall of plague. It tends to become evenly endemic in such places where climatic conditions are equable, *viz.*, Lower Burma and the Nilgiris. It shows violent fluctuations in the Punjab where great variations of temperature and humidity occur. The first Bombay epidemic (1896) was at its highest in December, the second reached its highest in February, and the third in March. The plague, however, constitutes a notable example of seasonal disease, its intensity being at its lowest ebb in July, gradually increasing till it reaches the zenith in March and rapidly declining during the next four months.

Prevention.—The preventive measures may be considered under the following heads, *viz.*—

A. Evacuation of the Infected Area.—As soon as the disease is recognised, if practicable, the infected village or locality should be evacuated and the inhabitants accommodated in temporarily built quarters or huts, while the infected ones and those adjacent to them should be thoroughly disinfected to destroy fleas. In cities evacuation is rather difficult ; when enforced it has sometimes met with serious opposition, and therefore requires careful control and organisation. Voluntary evacuation when uncontrolled, has too often taken the form of a stampede which carries the disease to the uninfected areas. Villagers, however, are now quite willing to evacuate as soon as dead rats appear.

These measures have proved a success only when properly organised by (*a*) the institution of infectious diseases hospitals ; (*b*) organised preparation of camps for evacuation of the infected quarters ; (*c*) the multiplication of the rural dispensaries ; and (*d*) a great increase in the rural area of the number of medical men capable of instructing the people in the benefits of sanitary measures, and of giving them preventive inoculations.

B. Campaign against Rats.—In cases of outbreaks it is important that one should remember the following points :—

1. That an intimate relation exists between rat plague and human plague.
2. That rat plague precedes human plague.

It follows, therefore, that the prevalence of plague depends on the density of the rat population.

(*a*) *Rat Elimination or the Prevention of Rat Infestation.*—This comprises such modifications in the habits, customs and

dwellings of a community as will result in a diminished rat infestation in the homes of the people and make the association between rats and men less intimate than at present.

(*b*) Measures designed to protect the rat population of any given town or village from plague infection.

(*c*) Rat destruction designed, as in (*a*), to diminish the chances of infection, and to keep the rat population at so low a level that, if plague be introduced, the severity of the resulting epidemic will be appreciably diminished.

(*d*) If efforts under these three heads fail to keep plague out, it is left to try and render the human population immune to attacks of the disease by means of inoculation, or to remove the population at risk from close association with infected rats.

1. Rat Elimination

1. *The Rat.*—The common Indian house rat *R. rattus*, is a very domesticated animal and is rarely found far from human habitations. For shelter it seeks the darkest corners of the dwellings, especially if such offer facilities for burrowing and a convenient supply of food. The rat possesses remarkable powers of climbing, and the ordinary *kutcha* mud wall offers no difficulties. A hard, smooth vertical surface free from irregularities and projections is not easily surmounted. A water-pipe or a drain pipe, which can be grasped by the rat's legs and tail, is easily climbed. A ledge, projecting horizontally 9 inches or more from the wall, if quite smooth and hard on the under surface, presents an insurmountable obstacle. A rat may succeed in jumping on to a ledge two and a half feet high, but not one three feet high.

Grain is the natural food of *R. rattus*, which is very largely vegetarian in its habits. Usually the rat favours that variety of grain which forms the staple food of the human population among which it dwells. Finally rats must have water if their food be dry ; sufficient water is obtainable from fresh, or wet, vegetables or grass.

A rat becomes sexually mature at a little over two months ; the most common number of young at a litter is five. The sexes closely approximate each other in number. So prolific are rats that, given sufficient food and shelter, a pair of rats may multiply into 80 pairs in the course of a year.

2. *Rat Elimination.*—Energetic and sustained rat destruction campaigns will do much towards keeping the rat population at a low level, with a conseqent markedly diminished risk of plague infection and the certainty of a much milder epidemic. Such measures necessitate sustained effort, because the rat is so prolific that if the campaign is relaxed the young rats will increase in exact proportion to the

amount of food available. Moreover, rat destruction campaigns are of only temporary benefit, and it is necessary first to consider whether the houses, habits and customs of the people cannot be so modified as to render the association between the rat and human population less close than it is at present. As things are, there is no limit to the amount of food and shelter that the average Indian house affords to the rat. Very little advantage is gained if the floors, walls and roof of buildings be so constructed as not to make it impossible for the rats to burrow therein, if such erections offer no lack of food and shelter to rats, and if ingress and egress through doors and other apertures be not prevented by some special devices. In many parts of India one can see buildings that have been made "rat-proof," harbouring, all the same, a very large number of rats.

Even in *kutcha* buildings something can be done towards eliminating the rat. All measures that lessen the amount of food and shelter for rats automatically effect a reduction in the number of rats. Protection of stores of food from the depredations of rats and efficient scavenging, are thus anti-plague measures of the first importance.

II. Protection of the Rats of a Community from Plague

Before embarking on a detailed description of active rat-destruction measures it will be well to consider how best to protect the rat population of any town from becoming infected with plague, or to make the ever present possibility of such an occurrence less likely.

1. *Grain and Plague.*—It is a common experience to find plague in towns and villages beginning in the close vicinity of markets and grain stores. The rat population of any given town or village is very much larger in the neighbourhood of market and grain stores than in other localities, with the result that when plague is present the rat epizootic is likely to be more wide-spread in such localities than elsewhere. It follows that grain exported from a plague infected town to another goes from the part of the town of despatch where plague is most severe to the part of the receiving town where the rat population is at a maximum. Further, grain and similar merchandise offer facilities for the transport of rats which baggage consisting of personal effects rarely affords. Plague infected rats are likely to be much more harmful as plague infecting agents than are fleas alone which, apart from their definitive hosts, are short-lived, especially if infective.

It follows, therefore, that the methods of grain storage and grain transport are of paramount importance in plague infected and plague threatened India, where the grain trade

is in a very special sense a "dangerous trade," and as such demands very close supervision.

In discussing this matter it is important to bear in mind certain facts regarding the habits of rats cited above. They explain the logical basis of the following *desiderata* of grain stores :—

(*a*) Wherever possible the wholesale storage of grain should be effected in buildings apart from those in which retail trade is carried on.

(*b*) Wholesale grain stores should not be situated in close proximity to densely crowded areas of a city.

(*c*) Wholesale grain stores should never be utilised for purposes of human habitation.

(*d*) Bearing in mind that water is essential for the life of the rat, no water accessible to rats, or fresh vegetables should be allowed in wholesale grain stores.

(*e*) As rats are unable to circumvent a smooth horizontal projection of 9 inches, such a ledge surrounding grain stores on the top of a plinth 3 feet high, is effective in prohibiting the ingress of rats. On the sides of the building in which the doors are situated, this ledge can conveniently be enlarged into a platform 2 feet or 2 feet 6 inches in width. Reinforced concrete is a suitable material for such ledges and platforms.

(*f*) The roof of the godown should overhang this platform and ledge to prevent the accumulation of rainwater thereon.

(*g*) No steps or similar means of facilitating ingress should be allowed. For unloading sacks of grain designed for such a store, the bullock cart can be pushed close to the platform, which is also at a convenient height to facilitate the deposit thereon of sacks.

(*h*) Rats will, from time to time, be introduced into such a store, but they will be compelled to leave in search of water and should find their return extremely difficult.

(*i*) In villages relatively rat-free stores can be made of almost any material, provided the roof is watertight, by raising the floor on uprights surmounted by rat-guards similar in design to those commonly employed on ships' cables. These uprights should be at least three feet high and would support the beams on which the floor rests. The floor might be made of wood. The space underneath the floor can be left open and kept free from weeds and rank growth with but little trouble.

2. *Other Means of Conveying Plague-infection.*—Clothing and bedding from plague infected houses may contain infected rat-fleas; they can be rendered innocuous by exposure to the direct rays of the sun. The ground used for the purpose should be so chosen that the sun is able to shine on it for the whole of each day. It should be flat, devoid of grass, stones, or anything which might afford shelter to fleas. Preferably it should be covered with a smooth layer of fine

sand three inches deep. The surface temperature of the sand should be at least 120° F. to ensure the destruction of all fleas. One hour's exposure in such conditions is sufficient for the purpose of destruction.

III. Rat Destruction

1. *Rat Poisons.*—Poison, if intelligently used, can accomplish much. The selection of a suitable poison is the most important consideration. The most satisfactory of all poisons, and the cheapest, is *barium carbonate.* As a rat poison it is certain in its action and safe to handle. Poison baits are best made as follows :—

One pound of powdered native barium carbonate is mixed thoroughly in an enamelled basin with three pounds of flour made from the grain which constitutes the staple food of the locality in which operations are to be carried out. Sufficient water is added to make the whole into a fairly firm paste. The resulting mass is sufficient for some 2,400 baits each containing three grains of poison, which are conveniently rolled into pill form. Clean hands and dishes are necessary to avoid imparting to the baits extraneous taste and odour which may diminish their attractiveness.

If rat poisoning be carried out with careful attention to all these details, a notable degree of success will be achieved, with appreciable benefit when plague threatens.

2. *Trapping.*—To effect a considerable diminution in the rat population and to keep it at a low level by means of trapping is a relatively expensive measure and one that requires careful and intelligent supervision.

Many rat-traps on the market are defective in design and construction. Traps selected haphazard have very varying degrees of efficiency, and observations have shown that the size of the trap, the size of the inlet, the strength of the trap, the accuracy with which the flap fits the frame designed for its reception, are all important points in determining the efficiency of the trap. Other things being equal, the larger the diameter of the inlet, the more satisfactory the trap.

Traps should be oiled only sufficiently often to ensure freedom from rust. Frequent washing of the traps is not recommended : rats are not attracted by cleanliness which appears to make them suspicious. Traps operated by a light counterpoised weight are more suitable than those worked by a spring.

All traps should be set overnight and collected early in the morning. All rats caught can be drowned or destroyed in some humane manner, their bodies being burnt. For systematic trapping a number of traps equal to 3 per cent. of the human population will be found sufficient. Frequent

nspection of traps, with the rejection for repair of all found lefective, is essential.*

The circular No. 49 of the 8th August, 1931 issued from the Office International d' Hygiene Publique laid down procedures for deratization of ships entering American Ports.

All non-infected ships coming from foreign ports are required to possess a valid six-monthly deratization or deratization exemption certificate. Otherwise they will have to undergo an inspection for rat infestation and if found infested to be fumigated, preferably when empty or with the least possible cargo on board, after which a deratization exemption certificate will be delivered to the ship.

Any ship coming from foreign ports, which within the preceding 60 days touched a foreign port in which human or rat plague has been notified during the preceding six months, and having tied up at the quay or taken on cargo likely to attract or lodge rats, will be treated as rat infested unless it has a valid deratization certificate dated subsequent to the call at the particular port.

Apart from the measures already described for the elimination of rats by having rat proof godowns, fumigation of plague-suspect goods is also an important line of defence. The different methods of fumigation have already been discussed (*see* page 442), but as a preventive for plague the ideal fumigant should possess the following qualities :—†

(*a*) It should be toxic to rats and fleas.

(*b*) It should be easily recognised by the senses in non-lethal concentrations.

(*c*) It should have penetrative powers and should not corrode metals and should not injure fabrics.

(*d*) It should be non-combustible and non-explosive.

(*e*) It should not have any ill-effects on foodstuffs and should not be absorbed by them ; and should be rapid in action and low in cost.

The following substances are used as fumigants, viz. sulphur dioxide (*see* page 432), chloropicrin (*see* page 434), hydrocyanic acid (*see* page 436), carbon monoxide and carbon dioxide, phosgene, ethylene oxide and carbon disulphide.

Carbon monoxide and *carbon dioxide* gases are employed for fumigation of ships in some Far Eastern ports and at Hamburg. But these are ineffective both as pulicides and bactericides and the possibility of the danger to human life from a high proportion of carbon monoxide collecting after fumigation in the compartments makes it less useful and dangerous.

Phosgene is carbonyl chloride. It is easily decomposed

* Summary of the preventive measures recommended by the Sanitary Commissioner with the Government of India.

† L. F. Hirst, *Fumigation of Plague-suspect Imports.*

in the warm damp climate of the tropics when it loses its efficacy; it also attacks metals.

Ethylene oxide has an adverse effect on the germination of seeds and is not recommended.

Carbon disulphide is an effective fumigant for disinfesting grain from insects. But the vapour is inflammable and explosive for large scale operations.

It should be clearly understood that both fumigation and rat proofing of premises should be regarded as complementary to one another as preventive measures for plague. It will be at once apparent that to fumigate goods and then to store them in rat-ridden premises will nullify any good result by exposing the goods to fresh infection from an internal source.

C. *Anti-plague Inoculation* (*Haffkine*).—The prophylactic use of vaccine is the most valuable method of personal prophylaxis. The bacilli are grown at 25-30°C. for two to six weeks in broth with a layer of *ghee* floating on the surface. This growth is killed by heat of 60°C. for one hour; carbolic acid 0.5 p.c. is then added to kill any organisms which may have accidentally gained entrance. Scutze has pointed out that vaccine made from cultures grown at 25-30°C. is less potent as an immunising agent than one grown at 37°C. The usual dose in 5 c.c. for an adult, and is injected into the outer part of the upper arm. The injection is followed by constitutional disturbance lasting for about twenty-four hours, and it makes the man unfit for work for two or three days. Haffkine's original vaccine has been much improved by Lamb and Liston, and Taylor and Sokhey and does not produce so much severe and prolonged febrile and local reaction. The immunity is established in about ten days after the inoculation and lasts for about six months, and often longer. Inoculate early during an epidemic. When once a bottle containing the vaccine is opened it should be used up; if any is left it should be rejected as after twenty-four hours it becomes unfit for use. The results of inoculation as attested by the Indian Plague Commission have been distinctly satisfactory, for although absolute protection is not afforded, this method of treatment diminishes not only the total number of attacks amongst the inoculated but also the percentage of mortality amongst those attacked. The conclusions of the Commission are:—

(1) Inoculation is harmless. (2) When given in the incubative stage, *i.e.*, before the signs of plague are apparent, it has in many cases the power of aborting the disease. (3) Inoculation affords to all those inoculated a strong protection against attack by plague. (4) In the few cases where inoculated people are attacked a very large proportion recover.

Disinfection.—To disinfect a plague-infected room the floor should be thoroughly swilled with kerosene oil or its

emulsion, or pesterine. Kerosene emulsion is made by boiling four cakes of sunlight soap in half a gallon of water and then adding 4 gallons of kerosene gradually. The fleas are found in the cracks and crevices in the floor. It is better to empty the room of all furniture; and infected clothes, bedding, etc., should be either burnt or disinfected by steam. The walls up to 2 ft. or 3 ft. should also be treated with kerosene. About two pints of oil are required for every square yard, and a few ounces of the oil should be poured into each rat hole. In case of pneumonic plague the room should be fumigated with formaldehyde.

Solution of perchloride of mercury or other chemicals are not of much value for disinfecting plague-infected rooms, where attention is chiefly directed against the destruction of rat-fleas which harbour the bacilli.

Pneumonic plague is most infectious as it spreads by inhalation. Attendants and nurses should always wear a mask when visiting patients. The best form of mask is a three-tailed gauze bandage with a pad of cotton-wool. This should always be destroyed after each exposure to infection.

Diseases Conveyed by Ingestion

Enteric Fever Group

Enteric fever is widely distributed all over the world, particularly in India.

Etiology.—The disease is caused by a specific micro-organism called the Eberth-Gaffky bacillus. It is a short, thick, flagellated, motile bacillus with rounded ends. In the early stage of the disease the bacilli are circulating in the blood. They occur in the urine in 25 to 30 p.c. of cases and can be isolated from stools in practically all cases at some stage. They have been found in the milk of nursing mothers.

The paratyphoid bacilli A, B and C resemble *B. typhosus* in their general morphological characters and staining reactions, but differ from it in biochemical and immunity reactions. Like *B. typhosus* they are non-lactose fermentors but produce acid and gas in glucose, mannite, maltose and dulcite. They cause a similar disease but are generally milder and are known as para A and B. Paratyphoid A is more common than para B.

Mode of Infection.—The great source of danger lies in the fæces and urine of the typhoid patients. The infection may be *direct* or *indirect*.

(*a*) *Directly* it is communicated to the attendants from want of proper precautions in handling patients or their excreta. Infection sometimes clings to the bed of the typhoid patient, and successive patients seem to get the attack when occupying the same bed. Direct contagion plays but a small

part in the production of epidemics, but is of value in causing localised outbreaks.

(b) *Indirectly* it is communicated through water and food infection. Many widespread epidemics are traced to this cause. The water of tanks or wells, once polluted, will spread the disease. Typhoid is essentially a food-borne disease. Milk and other articles of food act as vehicles of infection by becoming contaminated either by carriers, flies, or infected water. Tanks and wells are often polluted by washing clothes infected with the excreta of typhoid patients and epidemics following the use of such infected water are common. A probable source of typhoid in Calcutta is the use of unfiltered water for domestic purposes. Cooking utensils, plates, cups, etc., are often washed with this water with the result that several cases occur in the same house. The bacilli undergo rapid development in milk without changing its appearance, and may exist for several months in sour milk and live for several days in butter prepared from infected milk.

Soil plays some part in the spread of the disease indirectly through water, dust and flies (*see* page 125).

Flies alternately visiting and feeding on infected fæcal matter and on food are also a great source of danger.

Typhoid bacilli can be discovered in the urine and stools of persons who have suffered from the disease for a considerable time after recovery. These carriers are a great source of danger (*see* page 355).

Season.—In temperate climates the disease is more prevalent in autumn and early winter. In India the disease is equally prevalent all the year round, and in Bengal it shows its maximum in the dry hot months.

Age, Sex, etc.—Both sexes and all classes and races are equally affected. But those who are exposed to infection do not always get the disease. Some families are more susceptible than others. It is said that one attack gives immunity, although two attacks within a year have also been recorded. Within a short time after recovery the immune substances disappear from the blood. but the relative immunity lasts for a long time, frequently for life.

Prevention.—The incidence of the disease diminishes with improved drainage and water supply. The prevention implies (1) diagnosis of all cases and recognition of the carriers; (2) destruction of the bacilli as they leave the patient. Therefore disinfection of the urine, stool, sputum and other articles contaminated by their excreta is of utmost importance. Stools, urine and other discharges should be received in vessels containing strong disinfectants, and should either be deeply trenched or cremated along with soiled rags, etc. Soiled clothes should be placed in a strong solution of carbolic acid and then boiled. Rigid methods of cleanliness by attendants should be adhered to.

It is almost impossible to lay down any rules for the management of carriers except isolation, cleanliness, disinfection of stools and urine, and selection of employment which gives no opportunity of infecting other people. There is no safe and reliable method by which a carrier can be freed from infection. Urinary antiseptics, excision of the gall-bladder and autogenous vaccines have all been tried to solve the problem of chronic carriers.

In all outbreaks the existence of the antecedent cases ought to be enquired into. The sanitary conditions should be carefully investigated, especially in relation to the house. The milk-supply requires thorough investigation, and this gives most trouble; since one has to consider the possible risk not only during storage and distribution, but also the possibility of contamination from infected water. Individual prophylaxis depends upon boiling all water for drinking purposes, protecting all food from flies and dust, disinfecting the hands with strong antiseptic lotion after nursing, and paying special attention to the condition of the stomach and intestines.

The results of inoculation and kitchen hygiene in the British army in India have yielded wonderful results. Inoculation, tracking down of the carriers, improved sanitation of the kitchen and control of flies and water-supply are measures calculated to eliminate the disease to a large extent.

Protective Inoculation.—As a protective inoculation against typhoid fever a vaccine was first prepared by Wright who demonstrated that injection of killed typhoid cultures into healthy persons produced enhanced bactericidal power in the serum of such men. From observations made chiefly in the British and Indian armies it has been found that the immunity following this inoculation is maintained at a high level for about one year, after which it gradually diminishes. The initial dose consists of 0.5 c.c., the second of double the quantity is given after an interval of ten days. Owing to the prevalence of paratyphoid fever the use of pure typhoid vaccine has been discarded and a mixed vaccine of typhoid and paratyphoid A and B has been substituted under the name of T.A.B. vaccine, which contains B.typhosus, 1000 millions; paratyphoid A, 750 millions; paratyphoid-B, 750 millions in 1 c.c.

There is generally some reaction after the first dose, which consists of a certain amount of febrile disturbance with headache and general aching. There may also be a slight local reaction with swelling of the glands, which lasts for a day or two. The experiences of the great European War testify to the high value of inoculation as a prophylactic beyond all doubt. According to Wright's statistics the case incidence amongst the inoculated was only 2.25 per cent.

with a mortality of 12 per cent., against 5.75 per cent., and 21 per cent. respectively amongst the uninoculated. In the army in India this inoculation is repeated every second year.

Dysentery

Dysentery refers to a group of symptoms characterised by frequent small stools with mucus and blood, accompanied by spasm of the sphincter ani and griping. It is very common in India and the extent of its morbidity and mortality will be evident from the fact that about 300,000 deaths from it occur annually in India.

Two types are common, *viz.*, (1) the *bacillary dysentery* due to Shiga or Flexner bacilli; and (2) the *amœbic*, due to *Entamœba hystolitica*. Some cases show a mixed infection with both types. Besides these two principal types, *Schistosoma mansoni*, *Balantidium coli*, *Giardia* (*Lamblia*) *intestinalis* also cause symptoms of dysentery, but they are not common in India. Of the different forms, the bacillary type is more common than the amœbic form, and of the bacillary type, infection with Flexner bacillus is more prevalent than with the Shiga strain. Amœbic dysentery is distributed in tropical and subtropical countries and is common in India, North and Central Africa, Southern United States and Southern America. Bacillary dysentery is common in both tropical and subtropical countries.

The mode of infection in all forms is through the mouth by *food* and *water* contaminated with the excreta of patients suffering from the disease. *Dust* and *fly* play an important part in the dissemination of infection. The fly may also be the carrier of *E. hystolitica* cysts which may be expelled with the stool unchanged and thus be conveyed to food. The cyst of *Entamœba hystolitica* survive outside the body for a long time in a cool moist place. The cyst wall is insoluble in the gastric juice but soluble in trypsin. It is possible that it passes through the stomach unchanged and becomes free either in the small or large intestine. Amœbic infection occurs in all ages and sexes, although it is uncommon in very young children as compared with adults.

Carriers.—Like typhoid carriers there are dysentery carriers. Amœba carriers pass cysts with their stools without showing any signs of the disease themselves and are apparently healthy but a source of great danger to the community. As a rule they are persons who have suffered from amœbic dysentery or diarrhœa and have not been completely cured. The bacillary carriers on the other hand are persons who have a definite history of a previous attack of dysentery. Most of the carriers of this group pass Flexner bacilli, Shiga carriers being comparatively less. These carriers infect the food or the water.

Prevention.—From what has been said regarding the transmission of the disease, prevention depends upon attention to proper cleanliness. This applies to water, the house, the kitchen, and the latrines. Rigorous steps should be taken for the cleanliness of the kitchen and the stool of the cooks should be repeatedly examined to see that they are not carriers. Flies play an important part in the spread of the disease, therefore, food should be properly protected and the excreta of dysentery patients disposed of as quickly as possible. The human carriers are more dangerous and difficult to trace and treat. Their presence in schools, boarding houses, jails and asylums is more dangerous, and should be traced and properly treated.

Prophylactic vaccines against bacillary dysentery have been tried but the results so far obtained are not enough to give a definite opinion on their value. *Bilivaccine* has also been used apparently with some success. The carrier of *Entamœba hystolitica* should be treated with emetine-bismuth-iodide or kurchi-bismuth-iodide.

The cleanliness of the latrines, safe disposal of the night soil, and avoidance of indiscriminate defæcation should be enforced. The passage of stools in the fields may be harmless during the hot months when the direct sun's rays will render any infective organism innocuous, but during the rains when the fæces are washed into the nearest tank, well or other sources of water, this method of open air defæcation becomes positively dangerous.

Cholera

Cholera is an acute, infectious, epidemic disease characterised by profuse purging and vomiting of a colourless serous material, by muscular cramps, suppression of urine, algidity, and collapse, the presence of a special bacterium in the intestine and a high mortality (Manson).

It is endemic in certain river districts in India, *e.g.*, Assam and the delta of the Ganges, and is principally a water-borne disease. It is sporadic in Calcutta and occurs in the epidemic form at certain times. The total number of deaths in Calcutta in 1929 was 2,571. It occurred in the form of minor epidemics in Europe during the Balkan War of 1913, and in the course of the last European War, especially in the Balkans and in Mesopotamia.

India is considered to be one of the chief sources of the infection of cholera, but it is not certain that Lower Bengal and the valley of the Ganges are the only endemic centres. Other endemic centres are to be found in Central Asia, in certain parts of the Federated Malay States, in Java and the Dutch East India, Indo-China, Philippines and probably Southern China.

Mecca plays an important part in the spread of cholera through Western Asia, North Africa and Europe.

Etiology.—The following are the conditions necessary for a widespread epidemic of cholera :—

1. The presence of the microbe.
2. A suitable medium and temperature for its growth outside the body.
3. Means of transport.
4. Susceptibility to the infection.

1. *The Virus.*—Koch in 1883 discovered in Egypt the comma bacillus supposed to be the cause of cholera. In 1884 he came to Calcutta and found the same bacillus in the stools of all the cholera patients then examined. It is a short, motile organism about half the length and twice the thickness of the tubercle bacillus. It is slightly curved like a comma. It grows in an alkaline medium at a temperature from 30° to 40° C. but does not thrive in an acid one. Its growth is arrested below 16° or above 42° C., and a temperature over 53° C. kills the bacillus. It is aerobic but is nevertheless capable of growing to some extent in the absence of oxygen. The primary source of the virus outside the regions where cholera is endemic is the intestinal discharges of persons suffering from, or who have recently suffered from, the disease. It has been detected in vomited matters, and its presence in the vomit is to be accounted for by the contents of the intestines finding their way into the stomach. The comma bacillus has not been recovered from the blood during life, although Greig found it widely distributed in the different organs after death. He believes that the germ is distributed by the lymphatic system. It has been found in the gall bladder and in the stools of convalescents after recovery.

2. It is essential that the cholera vibrio should find some suitable medium outside the body for its growth. Such media are : (*a*) soil polluted with organic matter, especially excreta ; (*b*) sewage-polluted water ; (*c*) milk and other food. Greig has found that cholera germs are very non-resistant and die within about four days if kept in a dark room.

A suitable temperature is also necessary for its growth ; warmth and moisture being important predisposing factors. On the other hand cold does not necessarily arrest an epidemic, as is evidenced by the various outbreaks in the Punjab where the temperature often comes down to zero. Epidemics generally occur in the late summer and autumn, and subside with the advent of winter, to appear again in the next summer. The maximum periods of epidemic cholera incidence in Bengal are April, May and November, and in the Punjab at the height of the rains.

3. *Transport.*—Although atmospheric moisture may convey the virus, it is not possible for the cholera germs to

be transported to long distances by the *air*. The principal means by which the virus is carried about are :—

(a) Human Intercourse.—It is well-known that cholera is disseminated by human intercourse, and follows the lines of communication by river, road. rail, or ship. Kabul, for instance, has always received the infection from India and has been the centre from which it has advanced westwards. In six of the pandemics cholera has followed the land route through Afghanisthan and Persia and then through the Caucasus to Russia and Western Europe. In other instances it has been carried *via* the Red Sea more or less directly to Egypt. Although man is invariably responsible for introducing the disease to any place, its spread depends entirely on the insanitary conditions, the primary cause being the liability of the drinking water to be polluted by the infected excreta. Although it travels along the trade routes, it never advances far unless along its path there are places where the sanitary conditions are such as will help the disease to take root and start upon its course afresh. The spread is greatly facilitated by the gathering of travellers at pilgrim centres, fairs and religious festivals *e.g.*, Kumbh mela at Allahabad, car festival at Puri, etc. (See Fairs and Melas).

(*b*) *Rivers*—A polluted river may carry infection for very considerable distances to towns situated on its banks. The infection is usually carried up the big rivers by boatmen.

(*c*) *Carriers.*—It is doubtful whether healthy contacts harbour the cholera vibrios and act as carriers. In the majority of cases the bacilli disappear from the stools within a week after recovery : although cases are on record where cholera patients passed the vibrios for more than ten days and even up to 3 to 4 weeks after an attack. It is generally held that the cholera vibrios show definite reaction to standard cholera anti-serum. The non-agglutinating types do not cause epidemics. Drs. Tomb and Maitra have shown that the disease is perpetuated by constant pollution of tanks by persons excreting the organisms though not actually suffering from the disease. D' Herelle and his co-workers however think that true cholera is spread only by the sufferers and not by so-called 'carriers'.

(*d*) *Drinking Water.*—When the virus finds its way into the general water-supply of a locality the disease becomes widely diffused. This is very common in villages where there is no proper water-supply, and when the tank or well becomes infected. Tanks are usually contaminated by washing soiled clothes and other infected articles in them. This is shown by the fact that the spread of cholera has decreased by the introduction of a pure water-supply.

(*e*) *Milk, etc.*—Milk is not only a vehicle for diffusion but also a medium for growth. Many widespread epidemics may be traced to milk infection.

(*f*) *Insects* play an important part in the spread of the disease mechanically, by settling on articles of food after having been in contact with infected materials. The common house-fly acts as an active agent, and it has been shown that the germs are capable of living for at least fourteen days in the fly.

4. Individual susceptibility counts for much in the matter of infection. Chronic alcoholism by causing gastro-intestinal catarrh predisposes to cholera.

Incidence of Cholera.—Cholera is in some respects a seasonal disease. According to Rogers absolute humidity is an important factor in the incidence of the disease. In Assam, Lower Bengal and Madras the seasonal incidence is different from other parts of India. It increases in October to December in these provinces owing to the absolute humidity remaining above 0.400 during those months, and falls in January and February when the absolute humidity is nearly down to 0.400. It increases again from Assam to the east of the United Provinces in March, in the west of the United Provinces in April, and in the Punjab in May with the corresponding rise of the absolute humidity over 0.400. During the humid monsoon periods it remains prevalent all over India, except flooded Bengal and Assam, and falls with the fall of the absolute humidity. In Batavia, Flu has pointed out that heavy rains do not cause cholera to be epidemic, while a single heavy shower is liable to bring on an epidemic outbreak. Heavy rain flushes out the rivers and streams, helps the growth of soil bacteria which kill the cholera organisms, and reduces the breeding of flies.

Prevention.—The prophylactic measures may be considered under the following heads :—

I. Personal Prophylaxis

1. Correct any tendency to dyspepsia and derangement of the stomach as the normal gastric juice is deficient and the stomach is full of alkaline mucus in these conditions. In man digestive disturbances are often an important predisposing cause of an attack.

2. Promote the secretion of the gastric juice by keeping the stomach always full, an acid medium being hostile to the life and growth of the cholera germs.

3. Avoid foods that may cause indigestion. Unripe or over-ripe fruits, shellfish, or foods in a state of decomposition should be avoided.

4. Avoid any food or drink while travelling by railway. Cold dishes, ice puddings, ice creams, etc., should be rejected and everything taken hot.

5. Avoid bazar-made aerated waters. Freshly manufactured soda water should not be taken, and three or four days must be allowed for the carbonic acid to exert its destroying action on the comma bacillus.

6. Water for drinking purposes and for washing dishes etc., should as a rule be boiled. Filters are not to be relied on. Weak tea, lemon juice, *dahi* or butter-milk, cocoanut water, can be used with impunity.

7. Diarrhœa during an epidemic should be promptly stopped as the cholera organisms are hurried out of the stomach before the acid secretion can act on them. For the same reason purgatives should be avoided.

Anti-cholera Inoculation.—The prophylactic anti-cholera vaccine contains 8000 millions killed vibrios per c.c. Of this 0.5 c.c. is given as the first dose and 1 c.c. as the second dose a week later. For mass treatment a single full dose is given without much reaction. The protection conferred lasts for about six months, but this period is sufficient to help the inoculated person to tide over an existing epidemic. To get the best results the vaccine should be fresh, not more than 3 to 6 months old. The local reaction is as a rule mild. There may be œdema and a painful infiltration at the site of the injection, rarely followed by any systemic disturbances. Rogers (*Bowel Diseases in the Tropics*) recorded a table showing about 150,000 inoculated in five outbreaks with a reduction of 92 to 99 p.c. as compared with about 150,000 uninoculated. The relative freedom of Java from cholera is ascribed in great measure to the large number of inoculation performed among the civil population of infected or threatened areas during the epidemic manifestation of the disease. Thus there were 15,222 cases of cholera in Java during 1918, and 12,184 cases during 1919; but following upon an intensive inoculation the disease almost disappeared. There were 54, 17, and 52 cases in 1920, 1921 and 1922 respectively with only one death in 1921. In 1912, 8000 Europeans were inoculated in Batavia and there was only one death as against 15 deaths amongst 2700 uninoculated. Subsequent experience obtained during the last Balkan and the European War placed inoculation on a firmer basis. Russell by carefully controlled experiments in Madras proved statistically the value of anti-cholera inoculation, and showed that the immunity developed after five days.

Bilivaccine.—It is claimed that this when taken by the mouth confers immunity against cholera lasting for about one year. The treatment is taken for three days and consists of one pill of vegetable bile to be taken on an empty stomach to be followed a quarter of an hour later by one tablet of vaccine. The vaccine tablet consists of 50 mg., killed or desiccated cholera vibrios representing from 60 to 70 billions of microbes. Its value has been well spoken of and may be tried when inoculation is not possible.

Anti-cholera Mixture.—Dr. Tomb of the Asansol Mines Board of Health, Bengal, advocated the use of a mixture of essential oils, both for the prevention and cure of cholera.

It consists of—Spt. etheris, 30 ms.; oil of cloves, oil of cajuput, oil of juniper, each 5 ms.; acid. sulph. aromat. 15 ms. Dose, 1 dr. in half an ounce of water, every half hour; total average dose being 8 to 10 drs. For contacts, 1 dr. in water once or twice daily as long as risk of infection exists. This mixture has given good results in the hands of Dr. Tomb.

II. General Prophylaxis.—This may be discussed under the following heads :—

1. *Notification.*—Early notification is of the utmost importance. In Calcutta this is obligatory by law. In villages, the village Chaukidars are ordered to report cases of cholera to the local police who has to report daily to the Health Officer, or the Civil Surgeon, during an epidemic. Early notification helps the adoption of immediate steps against the disease before it has time to spread. But to be successful every step should be taken as early as possible. For this purpose, quicklime, posters, etc., should be kept in each Union Board, and the Chaukidars and Duffadars trained in their use. Cholera prevention centres should be established at convenient places where supplies of cholera vaccines and chemicals required for sterilising water and disinfecting clothes, excreta, etc., should be kept.

2. *Isolation of Cholera Cases.*—The isolation of the sick and segregation of the contacts are possible only in towns. But in villages all that can be done is to instruct the inmates of the infected houses not to mix with other villagers and at the same time to warn the villagers not to visit the infected houses, or to take water from the same source.

3. *Sterilising Water.*—Although cholera germs may be carried by means of flies from infected excreta to food, or more directly by the handling of food by human carriers, thus giving rise to sporadic cases of the disease, the fact still remains that in the vast majority of instances explosive outbreaks of cholera are almost always due to the use of infected water. Water, polluted by the excreta of cholera patients or carriers, is the chief factor in the spread of epidemic cholera, and that when the necessity arises for preventing or controlling the spread of such epidemics, the measures called for are primarily those aimed at the protection of all water-supplies from contamination, and the immediate disinfection of those supplies which are believed to have been exposed to risk of pollution. A supply of pure water and prevention of its pollution is of primary importance whenever there is any suspicion of cholera.

The following different methods may be adopted for purifying drinking water for the prevention of cholera, *viz.* :—

(*a*) Boiling.
(*b*) Chlorination.
(*c*) Permanganate of Potash.
(*d*) Reservation of Tanks.

(*a*) *Boiling.*—By this simple method the infected water may be purified most easily and efficiently. Since it is not possible to boil water for the whole community, individual house holders will have to remove the chief source of danger of cholera infection by this simple procedure.

(*b*) *Chlorination.*—In *bleaching powder* or *chlorinated lime* and solutions of the hypochlorites, we possess agents of extraordinary efficacy in the disinfection of water. Experience in the recent war has conclusively proved the special value of systematic chlorination of water-supplies as a practical measure of prevention against cholera and other water-borne diseases (*see* page 37). *Chlorion, electrolytic chlorine, chlorogen* are the preparations generally used for household purposes.

(*c*) *Permanganate of Potash.*—This has already been discussed on page 36. It should be however noted that d'Herelle is not a believer in the use of permanganate for the disinfection of water during cholera epidemics. He holds that to be of any use the water becomes undrinkable for several days and the process interferes in the dissemination of bacteriophage, which according to him has a controlling effect in epidemics (*see* page 421).

(*d*) *Reservation of Tanks.*—The cholera organism is very easily destroyed. Thus the water of an infected tank will purify itself and become safe for use if it is exposed to air and sunlight for a few days. The use of a tank, suspected of being infected with cholera, should be rigidly forbidden for a definite period. In dry weather three to four days are enough, while on wet or cloudy days seven to eight days are necessary. Tanks that are not overshadowed with trees and vegetation will purify themselves most rapidly. Natural purification is very slow in wells and should not be relied upon.

4. *Protection of Food.*—This is of utmost importance specially during an epidemic. Food should be well cooked and properly protected from flies, dust, etc. Uncooked food should be avoided, and no one should be allowed to handle food without thoroughly washing and disinfecting the hands. This should apply more particularly to servants and cooks. Special attention should be paid to the cleanliness of cooking utensils, plates, cups, etc. Bazar food should be avoided.

The following additional precautionary measures should be adopted for the safety of the community at large :—

1. All sources of water-supply should be protected and all infected tanks and wells should be placed under guards for at least a week and no one should be allowed to use the water under any circumstances.

2. Persons from infected houses should not be allowed to dip their buckets into an uninfected well or tank, and should not be allowed even in their vicinity.

3. While arranging to secure efficient treatment for actual cases, the greatest emphasis should be laid on preventing the spread of infection.

4. Arrangements for drawing water should be made through a man especially appointed for this purpose.

5. Particular attention should be paid to the cleanliness of the cook and of the cook-house.

6. All privies and drains should be daily disinfected.

Cholera is one of the diseases included in the International Sanitary Convention (*see* page 414). The Convention provides for the telegraphic notification to all contracting parties and to the Office International d'Hygiene Publique, of the first recognised case occurring in the territory of any Government concerned, or of the first recognised case of the disease that occurs outside the limits of local areas already affected, together with an account of the measures taken.

Disinfection.—This is of utmost importance and must be complete and thorough. It includes the disinfection of the discharges, the excreta, the room, the clothing, the utensils, *e.g.*, cups, plates, etc. For a detailed description see pages 439-444.

Bacteriophage in the Treatment and Prevention of Cholera.—The nature of bacteriophage and the underlying principles of its use in the treatment and prevention of certain epidemic diseases have already been discussed (*see* page 420). Although much work has recently been done by d'Herelle, Morison and others in India on the use of phage in the treatment and prevention of cholera no definite conclusions have yet been reached on its value. If a person is attacked with cholera, d'Herelle holds that his recovery is impossible unless he develops the bacteriophage for cholera in the intestines. Simple though it is in theory it has been found equally difficult in practice. However, phage has been used to patients attacked with cholera and also as a preventive by applying it to different water supplies and giving it orally to contacts. The idea of giving phage to patients is to breakdown the cholera vibrios in the intestinal canal. But the results so far obtained have not been convincing. On the other hand its use as a prophylactic has given different results, and the whole matter from the public health point of view may be held to be still *sub judice*.

The methods of employing it are as follows :—*

(*a*) *For treatment* phage is administered by mouth in 2 c.c. doses three or four times a day on an empty stomach,

* Phage is supplied in sealed ampoules. Ampoules showing turbidity should be rejected. The contents of an ampoule should be used immediately it is opened and on no account should be kept for future use.

followed by a glass of water. As much as 20 c.c. can be given in twenty-four hours in severe cases. If there is improvement phage is given on the next and subsequent days till the patient recovers. During the administration of phage it is necessary to withhold other remedies such as dilute acids, essential oil mixtures and intestinal antiseptics. These are supposed to destroy the phage and prevent its efficient working.

(*b*) *For prophylaxis* of contacts and others phage is given orally in 2 c.c. doses in the same way as it is given to patients. It is not given daily but only once or twice a week during the prevalence of an epidemic. Morison's method of giving phage as a prophylactic is based on the belief that phage can convert an infective vibrio into a non-infective one. He therefore administers phage to the first cases of cholera or severe diarrhœa and dysentery occurring in villages. (See Morison, *The Use of Bacteriophage for the Prevention of Cholera*, Indian Journal of Medical Research, March, 1934). It is also used for sterilising unprotected drinking water supplies. In the case of *wells*, the quantity of water is first estimated and then 1 c.c. of phage is added for every 100 gallons of water removed from the wells. In the case of water from *rivers, tanks* and *tube wells* used for drinking purposes and stored in houses, phage is added daily to the water, 1 c.c. being added for all quantities below 100 gallons stored.

Anti-cholera Propaganda.—This is likely to be very effective during an epidemic. The people should be taught the principles underlying cholera infection, how the disease spreads, and the method of its prevention. The importance of protecting themselves by inoculation and the value of preventing the water-supplies from pollution by human excreta should be forcibly brought home to them. It should be explained to them how to purify the water, and still more how boiling the water will help protection. The importance of disinfecting the floor, clothing and utensils, and the use of soap and water for cleansing the hands must be insisted on. In this educational work the use of posters and leaflets is of great advantage. Under certain conditions popular lectures, illustrated by magic lantern slides, are likely to be helpful, and full use should be made of every opportunity to employ them.

Weil's Disease (Leptospirosis)

Infectious Jaundice, Spirochætal Jaundice

It is an infectious disease characterised by high fever, often jaundice and enlarged liver and sometimes enlarged spleen; the causal organism being *Leptospira icterohæmorrhagiæ*.

Distribution.—It is common in Japan amongst the miners, and is known to exist in Egypt, on the shores of Mediterranean and the North African Coast. Outbreaks occurred during the last Great War in Gallipoli and Salonica. Its occurrence in recent times has been reported from the Andaman Islands, the Malay States, Queensland and Scotland. The Bulletin of the Office International d'Hygiene Publique (October, 1934) reported its prevalence in Japan, United States, France, Germany and Sweden. Its association with water workers in Holland and wetness of the mines has been proved. Those working in rat infested areas like refuse dumps, piggeries, breweries and sewers are largely affected. Recently the outbreak of the disease among persons employed in the handling and cleaning of fish in Scotland and amongst cane cutters in sugar-cane areas of Ingham (Queensland) has been described (*British Medical Journal*, December, 22, 1934).

It Japan it occurs during the months of September to November, while in Europe it occurs during the summer.

Etiology.—The organism responsible is a spirochæte, *Leptospira icterohæmorrhagiæ*, found as a harmless parasite in the kidneys of rats, *Rattus rattus* and *R. norvegicus*, and is found in the urine and fæces. Its presence has not been demonstrated in the blood. Infection takes place either by inoculation, the portal of entry being through abrasion, or through contaminated food. Bathing in infected water gave rise to epidemics. Infection of water or food takes place through contact with contaminated rats.

Prevention.—This consists mainly of protection of food and water. Infected stools and urine should be made harmless by proper disinfection or disposal. Efforts should be made to eliminate the rat population. A vaccine prepared from the killed cultures has been used with much success as a preventive in Japan and other places. Taylor and Goyle recommended in the Andaman Islands the treatment of infected water by calcium cyanide. The spirochætes can not live in acid water and the use of acids has also been recommended.

The following preventive measures have been advocated by the Public Health Commissioner, Ingham (Queensland) where several cases have occurred amongst the cane cutters in the sugar-cane areas :—*

"1. Avoid eating food in the fields unless the hands are thoroughly cleaned previously.

2. Avoid drinking water in the fields unless it has been boiled.

3. Avoid rolling and smoking cigarettes in the field.

* J. Grahame Drew, *British Medical Journal*, Dec. 22, 1934.

4. Avoid using water lying in the field for washing hands and face ; such water is liable to be infected.
5. Avoid walking through or in wet places.
6. Feet should be protected by wearing boots.
7. All cuts and abrasions should be washed immediately in a perchloride of mercury solution (1 in 1000).
8. All cuts and abrasions, after the above preliminary treatment, should be covered with adhesive plaster or other suitable covering.
9. All food in barracks and elsewhere must always be protected from rats."

The fact that the disease occurs amongst coal miners, bargemen, sewer workers, fish workers and cane cutters, indicates the necessity for regarding it from the standpoint of occupational disease.

Diseases Conveyed by Droplet Infection

Diphtheria

Diphtheria is an infectious disease, usually of the mucous membrane of the throat and characterised by local fibrinous exudate, transmissible from the sick to the healthy—the cause being a micro-organism (Klebs-Loeffler bacillus). The constitutional symptoms are due to toxins produced at the site of the lesion.

Etiology.—Diphtheria is a widely spread affection, and like most infectious diseases is prevalent only in certain seasons. The influence of soil and rainfall upon the prevalence of this disease has led to much discussion and debate.

Epidemics usually commence with the advent of the cold weather, and the maximum death rate is reached in November and December. It is common in the hills during the rains.

It is believed that sore throat or some damage to the mucous membrane of the throat like catarrh, measles, scarlet fever, etc., predisposes to attacks of diphtheria ; but some people are peculiarly susceptible to it.

Although no age is exempt, it is generally believed that the disease is commonest in children, specially between the ages of 3 to 5 years. Out of 3000 cases recorded by Rolleston less than 1 p.c. were under one year. It becomes less frequent with the approach of adult life and is rare in old age.

Schick has shown that the presence or absence of immunity against diphtheria can be ascertained by a special test known as the "Schick Reaction". This is done by injecting intradermally on the front of the forearm $\frac{1}{50}$th of the minimum lethal dose of diphtheria toxin for a guinea pig weighing 250 grms. in 0.1 c.c. or 0.2 c.c of normal saline (Schick Test Toxin). 0·2 mil (3 ms.) contains the test dose. A control

test is made on the opposite arm with "Schick Control" which is Schick test toxin heated to 75° C. for not less than five minutes to destroy all the toxin. A positive reaction indicates that the individual is susceptible to diphtheria, *i.e.*, there is no antitoxin in the circulating blood, and this is shown by the appearance within 24 to 48 hours of a circumscribed area of redness which reaches its height on the 4th day. A negative reaction indicates that the subject is immune to diphtheria, *i.e.*, there is an appreciable amount of antitoxin in the blood (1/30 unit per c. cm.) to neutralise the toxin and is shown by the absence of reaction in either arm. A pseudo-reaction is characterised by the rapid development *within* 24 hours of a red flush, equally marked in both arms. It is due to hyper-sensitiveness of the person to protein present in the toxin injected. It is less circumscribed than the positive reaction and disappears by the fourth day.

Mode of Spread.—The most common mode of spread is by personal communication, chiefly through the *carriers*, whether sick or healthy. In the majority of cases the disease is spread by *droplet infection*, the bacilli being expelled from the mouth and nose by coughing, sneezing, spitting or even by speaking. It may also be transmitted by discharges from the middle ear or from wounds which are the seat of diphtherial infection. A number of cases have been traced to consumption of milk (*see* page 206). The so-called diphtheritic affections of pigeons, poultry, and calves are as a rule diseases quite distinct from human diphtheria, and are not communicable to man.

The *incubation period* is short and varies from a few hours to five days.

The diphtheria bacillus is a relatively hardy bacteria, and its virulence is not affected by drying or cold, but sunlight has a deleterious effect. Objects contaminated by the patient, such as toys, clothes and bedding, may remain contagious for a long period, specially if they have been kept in the dark. Dudley has shown that the use of pens, pencils, and slates by the scholars in common may be responsible for outbreaks.

One attack gives no protection against a second one. The period of infectiveness has been variously estimated; so long as the bacilli are present in the throat infection must be possible, and the length of time for which they may occasionally persist is remarkable. They may disappear within three days of the disappearance of the membrane, or may last for as long as three weeks. Hewlett mentions a case where it persisted for no less than fifteen months after the attack. It is not safe to allow convalescents to mix with healthy children until after the disappearance of the bacilli from the throat, and this point can only be definitely

ascertained by bacteriological examination of smears from the throat.

Prevention.—This is best described under the following heads, *viz.*—

1. Isolation and Disinfection.
2. Production of Artificial Immunity.

1. Isolation and Disinfection.—Prior to the introduction of antitoxin these were the only methods in use for the prevention of the disease. The patient may be isolated either in a hospital or in a large well-ventilated room in a private house. The period during which the patient requires to be isolated should be determined by clinical considerations. In the absence of any discharges from the nose and ears or sequelæ in the form of albuminuria or paralysis, the patient who has had a mild attack may be set at liberty at the end of a month. In cases of any severity the period of detention should be prolonged to at least six weeks, most of which should be spent in bed.

Disinfection as carried out, *viz.* spraying of the infected room with formalin, and steam disinfection of the infected bed and clothing, has very little effect in the prevention of the spread of the disease. Disinfection of the carriers is a matter of considerable difficulty. Numerous local applications have been recommended, but their action is uncertain. The persistence of the carrier state is usually due to some local infection, *e.g.*, chronically inflamed tonsils, adenoids, or affection of the nasal sinuses.

2. Production of Artificial Immunity.—(*a*) *Passive Immunisation.*—Diphtheria antitoxin has been employed for the purpose of conferring immunity in persons exposed to diphtheria. This prophylactic inoculation becomes efficient after 24 hours and remains so for about 3 weeks. The usual dose of the antitoxin is 500 units irrespective of the age. There are however certain drawbacks to passive immunisation, *viz.* (*a*) the protection does not last for more than 3 to 4 weeks; (*b*) it renders the patient hypersensitive, *i.e.*, he may develop anaphylaxis if a therapeutic dose of serum for any disease is given within the course of the next few years; (*c*) it interferes with the process of active immunisation by toxin-antitoxin.

(*b*) *Active Immunisation.*—The protection afforded by passive immunisation or injection of antitoxin is only temporary, whereas a more durable and possibly permanent immunity is conferred by a standardized mixture of toxin and antitoxin. This is specially indicated for nurses, schools, hospitals, orphanages, etc., after a preliminary Schick test. The method consists in giving three subcutaneous injections of a mixture of toxin and antitoxin at one week's interval. The usual dose is 1 c.c. For a child under one year the dose is 0.5 c.c. The 1st dose contains equal parts of toxin

and antitoxin, the 2nd dose one part of antitoxin and two parts of toxin, the 3rd dose, one part of antitoxin and three parts of toxin. The injection of toxin-antitoxin mixture was followed by untoward effects, some due to contamination with staphylococci, but others from free toxin contained in the mixture. Therefore the mixture which contains free toxin is not used now as it is possible to use a toxin which has been so modified that while retaining the activity as an immunising agent it has no toxic properties. The following different forms of diphtheria prophylactics are now available.

1. *Toxin-antitoxin mixture*, prepared by adding diphtheria antitoxin to the filtrate. Owing to the objections just mentioned this mixture is not so much used nowadays.

2. *Toxoid or anatoxin*, prepared by treating the filtrate with formaldehyde so that the toxin is completely "toxoided". Its use is followed by somewhat greater local reaction than there is with toxin-antitoxin mixtures or with the toxin-antitoxin floccules. But this is not so severe as to militate against its use.

3. *Toxoid-antitoxin mixture*, prepared by treating the filtrate with formaldehyde, and adding a small quantity of diphtheria antitoxin. It is free from the local reaction produced by anatoxin and has been extensively used in England since 1924.

4. *Toxin-antitoxin floccules*, prepared by adding diphtheria antitoxin to the filtrate in the proportion necessary to produce a suitable flocculation, separating the floccules, and washing and suspending in normal salt solution. When injected it provokes formation of antitoxin due possibly to slow dissociation of the floccules into their constituent parts. It causes no inflammation at the site of injection. It has however no advantage over the next, and the use of active toxin in its preparation makes it less suitable for human immunisation.

5. *Toxoid-antitoxin floccules*, prepared by treating the filtrate with formaldehyde, adding diphtheria antitoxin in the proportion necessary to produce a suitable flocculation, separating the floccules, and washing and suspending them in normal salt solution. This is the best form of diphtheria prophylactic and is absolutely safe for immunisation of children. The immunity following the injection of floccules comes on rapidly. The floccules give practically no reaction.

6. *Toxoid precipitated by alum*, prepared by precipitating and washing free from all non-specific material by the addition of 1 p.c. potash alum, promises to be a valuable form of diphtheria prophylactic.

When once diphtheria has broken out in a community, such as schools, hospitals, boarding houses, orphanages, etc., the whole population of the institution should be Schick-

tested and the following procedure advocated by Okell, Eagleton and O'Brien should be followed: "(1) Schick-negative reactors are not usually susceptible to diphtheria; (2) Schick-positive reactors are susceptible to diphtheria; (3) Schick-positive reactors never harbour virulent bacilli detectable by ordinary sub-culture methods unless they are suffering from or incubating diphtheria; (4) carriers of virulent bacilli are immune and are always *negative Schick-reactors*; (5) 'avirulent' bacilli do not cause diphtheria, and therefore 'avirulent carriers' are of no importance to the public health authority; (6) one efficient swabbing of a population gives a sufficient working knowledge of the location of infection—*i.e.*, all 'profuse' and therefore dangerous, carriers will be detected."

On the results of swabs and of virulence tests the cases may be classified as follows:—

A. Schick positive, swab negative.
B. Schick positive, swab positive, bacilli avirulent.
C. Schick positive, swab positive, bacilli virulent.
D. Schick negative, swab negative.
E. Schick negative, swab positive, bacilli avirulent.
F. Schick negative, swab positive, bacilli virulent.

A and B are harmless but susceptible and should be separated from dangerous carriers. Class C are uncommon, and will develop signs and symptoms soon but should be watched and treated with antitoxin.

D, E and F are isolated from the first. D are harmless and immune. E are of the same class. F are dangerous carriers and should be kept apart from all susceptibles *from the start*.

Other preventive measures to be adopted are the same as those described under small-pox. Particular attention should be paid to the discharges from the nose and throat.

SMALL-POX

Small-pox or variola is a contagious specific fever, attended on the third day of illness by characteristic eruption of the skin, first papular and ultimately pustular.

Alastrim is a mild form of small-pox sometimes known as *variola minor*. It is less severe and is protected by vaccination.

Small-pox is known to have been indigenous to Eastern countries and its earliest records are from India and China. Its distribution is world-wide and it is essentially an epidemic disease, although it must be regarded as endemic nearly everywhere in India. Small-pox rages epidemically in Bengal every five to seven years during the month of March and the two months following it, and sometimes until the rains. In India the maximum prevalence of the disease is

during the hot weather: while in cold countries it is most prevalent during the late winter and early spring. The prevalence and mortality of small-pox are much influenced by vaccination.

This is one of the most virulent and infectious of transmissible diseases, and persons unprotected by vaccination are almost universally attacked on exposure. The mortality appears to be higher among males than among females, and the disease is most fatal in children between the ages of two and four. The death-rate from small-pox in India varies from 0.3 to 2.0 per 1000 per annum, and about 20 per cent. of the persons attacked die. In 1909 there were 3784 deaths from small-pox recorded in Calcutta and after that the city was practically immune. In the years 1910, 1911, and 1912 the total number of deaths were 48, 41, and 77 respectively. In 1927 there were 42,514 deaths in Bengal.

Infectivity.—The *incubation period* of the disease is usually twelve days, but it may be as short as five days, or as long as three weeks. The disease is infectious from the earliest period of its manifestation, probably through the breath, and the danger continues during the whole course of its progress, but particularly after the pustular stage, when the scales begin to separate. Therefore the patient should be isolated until the last scab has fallen off. The ratio of persons who are entirely insusceptible to small-pox is, according to Notter and Firth, 1 in 20 for adults and 1 in 60 for children. The contagion is very perisistent, and it may act through a considerable distance. It is exhaled from the skin and lungs of the patient, is probably contained in the secretions and excretions, and adheres to clothing, articles and places with which the patient may have come in contact.

Transmission.—The commonest cause is perhaps direct contact or proximity to a case—a proximity close enough to allow the throat or nasal secretions or skin debris to be inhaled by the person infected. Air is the medium through which the contagion is chiefly transmitted. Houses within a radius of half a mile of a small-pox hospital have been attacked at three times the rate of those between half a mile and a mile, and at four times the rate of those beyond a mile. Whether the disease is spread through the air or through the carelessness of persons connected with the hospital is still disputed, and in the absence of any exact knowledge it is better to locate small-pox hospitals as far from inhabited areas as possible.

One attack generally confers immunity for the rest of the life. A second attack, however, is not uncommon and may occur even after an interval of one year; and a third attack is not unknown. The protection, however, tends to wear off in course of time. It should also be borne in mind that

complete natural immunity even after repeated exposure is occasionally seen.

The cause is not known, although various organisms, among other two or three protozoon-like bodies have been described. But these have not received general acceptance. All the evidence goes to prove that the causal agent is a virus.

Prevention.—The following measures should be adopted during an outbreak of small-pox :—

1. Vaccination

By *vaccination* is meant the introduction into the human system of *vaccinia*, which is cow-pox, an allied disease. Instead of a general eruption all over the body vesicles appear only at the points of inoculation.

Inoculation.—The fact that an attack of small-pox confers immunity was recognised quite early, and thus originated the method of conferring protection against small-pox by inoculation, which consisted of inoculating the variolous matter into a wound. This method was practised in India before the introduction of vaccination, but has been given up in favour of vaccination. The method was not without some danger, and severe reaction ending fatally often followed inoculation. Moreover the inoculated disease was as infectious as true small-pox to the unprotected. It may, however, be justified under emergencies, *e.g.*, in isolated places or islands where vaccine virus is not available at the time.

Jenner in 1798 first pointed out that the inoculation of man with cow-pox (*vaccinia*) confers immunity from subsequent attacks of small-pox in the same way that an attack of small-pox does to a patient. Many experiments were made to confirm these results, and the practice of vaccination became general.

Duration of Protection.—The protection afforded by vaccination is less perfect and less permanent than an attack of small-pox. The susceptibility to small-pox after a primary vaccination returns slowly, and the duration of protection afforded by vaccination depends upon (*a*) the quality of vaccination, *i.e.*, the number, area, and character of the scars; (*b*) the time which has elapsed since its performance; (*c*) the mode of its performance—vaccination in three or four places gives better protection than that conferred by vaccination in only one spot. Whenever possible primary operations should be performed at six points, though vaccination in two points in infants has been recommended followed by re-vaccination at school age.

Vaccination was made compulsory in Calcutta in 1880. The mean ratio of deaths per 100,000 of the population per annum for nineteen years previous to this was 116.8, and for nineteen years subsequent 44.5.

Small-pox can be almost entirely prevented by vaccination. Formerly the disease was so prevalent that almost every one suffered from it. As a result of the extensive use of vaccination the disease has almost been exterminated from many countries. Thus there were only 8 deaths in the year 1897 in the entire German Empire with a population of 54,000,0000.

A widespread epidemic of small-pox can only be attributed to ignorance concerning the prevention of the disease by vaccination and re-vaccination. As full protection does not last beyond seven years, it is advisable to be re-vaccinated at intervals of 7 years. By immediate vaccination, all persons brought directly or indirectly in contact with the case, the progress of the disease can almost at once be checked. It is therefore necessary that the physician, the attendants, the relatives of the patient, and in fact all the inmates of the house should be vaccinated. If possible the residents of the adjacent houses should also be vaccinated. Even after exposure to infection an attack can be warded off, because the incubation period of small-pox is twelve days and the full protection of vaccination is attained before the possible development of the disease. If, however, the disease is contracted it generally appears in a much milder form. If persons exposed to small-pox are not vaccinated they should be placed under quarantine for sixteen days from the date of last exposure. No person who has not been vaccinated within five to seven years, and no person who has had small-pox for seven to ten years previously should rely upon the supposed immunity.

Natural insusceptibility to vaccination is sometimes observed, when even fresh virus carefully applied repeatedly fails. These cases are probably also immune to small-pox; nevertheless they should be vaccinated during an epidemic, since we have no means of ascertaining when this natural immunity may lapse.

The following analysis of 5000 cases of small-pox shows the influence of number of scars to mortality.—

	Per cent. mortality
Unvaccinated	35
No cicatrix	23
One cicatrix	7.7
Two cicatrices	4.7
Three cicatrices	1.9
Four cicatrices	0.05
Re-vaccinated	nil.

The Operation of Vaccination.—This consists in introducing vaccine virus under aseptic conditions into the skin (never under the skin or subcutaneously), and is usually done on the outer side of the arm near the insertion of the deltoid muscle. The anterior surface of the forearm 2 in. below the

bend of the elbow, or the calves of the legs are also selected. When given on the legs, the abundant lymphatics on the groin control better the inflammatory reactions. But it is more exposed to injury and is not possible to keep the part clean specially with children. The part should be thoroughly washed and cleansed with soap and water, and then with some antiseptic lotion, and finally flushed with clean water to remove all traces of the antiseptic. The lymph taken on the point of a sterile lancet is inserted by punctures. Strong antiseptics will counteract the object of vaccination. Absolute alcohol is therefore better and should be allowed to evaporate after having done its work. The vaccinating lancet can also be sterilised by wiping with absolute alcohol or rectified spirit.

Instruction to Vaccinators.—1. Vaccinate only healthy subjects. Infants suffering from fever, irritation of the bowels, skin eruptions or eczema should not be vaccinated.

2. Do not vaccinate in a house where there is a case of erysipelas.

3. Since there is some relation between the number of scars and the degree of immunity, it is necessary to make at least four insertions, and care should be taken to make the insertions so far apart that they do not run together and form one large sore. The area should be covered with a clean cloth after allowing some time to dry. Painting with a solution of picric acid in alcohol, markedly lessens local reaction and danger of secondary infection, without interfering with the success of vaccination.

4. Particular care should be taken to protect the vesicles; the crusts should be left until they drop off. Ordinarily no dressing is required.

5. In primary vaccination only enter as "successful" those cases in which the typical vaccine vesicles have been produced; in re-vaccination only those in which vesicles, either normal or modified, or papules surrounded by areolæ, have been produced.

6. Primary vaccination should be inspected between 6 to 8 days, re-vaccination between 24 to 48 hours, otherwise the definite reaction may be missed and the case entered as unsuccessful.

7. Whenever practicable vaccination should be done with preserved calf vaccine. In arm to arm vaccination ascertain that the children you take the lymph from are of healthy parentage, and have no signs of any hereditary disease, especially syphilis. Lymph should be taken from typical vesicles around which there is no conspicuous commencement of areola. The practice of vaccinating direct from the calf or from arm to arm is to be discouraged.

8. When performing a number of operations use two lancets; put the used one in boiling water for sterilisation.

9. The suitable method is by shallow oblique punctures so as to make valvular incisions without penetrating the skin. The part should be stretched and the lancet held at an angle. The German law allows only incisions to be made with a sterile needle or the point of a scalpel which should not be deep enough to draw any blood. Scarifications or cross-scratchings are forbidden, as they form a large abraded surface which soon becomes covered with a dry, hard crust of serum and blood, through which the eruption cannot pierce.

A vaccinator should vaccinate at once all the members of a household or contacts in case of an outbreak of small-pox in the house, and also re-vaccinate people during epidemics, irrespective of the length of time that has elapsed since the last vaccination.

Complications of Vaccination.—Vaccination may give rise to the same group of complications as any other open wound and may be avoided by proper aseptic precautions. But within recent years cases of *post-vaccinal encephalitis* have been reported; a complication though of rare occurrence, is disquieting because of its high death-rate. It appears 9 to 12 days after vaccination, the onset being abrupt and accompanied by headache, vomiting and drowsiness passing on to coma. One case was first reported in 1912. Subsequently four cases were reported from the London Hospital in 1922. Between 1922 to 1927, 93 cases have been recorded in England. 69 to 96.6 p.c. of cases occurred in primary vaccination of children between the ages of five and fourteen years. Practically it does not occur in primary vaccination of infants or in secondary vaccination. The cause is still obscure, although three views are held, *viz.* (*a*) that it may be due to vaccinia virus; (*b*) that infection with the vaccinia virus may flare up a dormant neurotropic virus which the patient was harbouring; and (*c*) may be toxic. It is possible that the condition is produced either directly by the vaccinia virus or indirectly by the activation of some unknown latent virus.

Age of Vaccination.—In Bengal the Vaccination Act enjoins that a child should be vaccinated within six months of its birth, but the best age appears to be four months, that is before the child can turn over. A properly performed vaccination, even to a new born babe, is practically without any danger. Children are very highly susceptible to small-pox, and the younger the child the less is the resisting power. If there be any reason to suspect that the child may develop small-pox, vaccination should at once be performed.

Phenomena of Primary Vaccination.—After an incubation period of from 3 to 4 days a slight elevation can be felt, and on closer examination one or more small papules are observed. After the fifth day the papule becomes vesicular which is at first clear and pearl-like. On the 8th day the

vesicle matures and in the centre there is a dry brown scab surrounded by a ring of irregular vesicles containing turbid lymph. Around this there is a brawny areola. The vesicle begins to be pustular and umbilicated on the 9th day, when it becomes greyish, tense and loculated, and when pricked the lymph only from the compartment opened exudes. Slight constitutional symptoms such as fever, enlarged glands, restlessness and itching are observed. About the 10th day the vesicle begins to dry up and only a dry scab remains about the 14th day, which falls off about the 21st day. The scar or cicatrix is depressed and marked with little pits.

Vaccination is not successful unless the areola or red zone around the vesicles is formed. When lanolinated lymph is used the areola commences to form on the 5th day, but with glycerinated lymph it takes about two more days for its development. The vesicles have a doughy feel and do not fluctuate as in the case when pus is formed. Vaccinia only begins to exert prophylactic power when the areola commences to form round the vesicle.

The *immunity* appears after one week, generally about the 8th day of vaccination. The precise nature of the changes which produce immunity is not well understood. But it is not of the nature of an antitoxin, although the blood of a successfully vaccinated person contains certain specific antibodies which render vaccine virus inert when brought in contact with it. The vaccine virus grows and produces an enormous number of colonies on the inoculated spot by the 8th day of vaccination, when the antibodies appear which attack and digest the colonies producing toxin causing local redness (*areola*) and fever. Soon however the micro-organisms are killed and the contents of the pustule become inert, the antibodies remain for a long time in the system. At this period the subject remains hyper-sensitive and if revaccinated there follows an immediate reaction of anaphylaxis.

2. *Isolation.*—The patient and the suspect should be separated. All communications between the sick and infected and the healthy (other than the attendants), and the movement of any article from the infected room or house, should be rigidly forbidden.

3. *The Sick Room.*—The contagion of small-pox harbours in carpet, beddings, clothing, etc., and therefore these and all unnecessary furniture, and any other article capable of harbouring infection, and which would be difficult to disinfect or not desirable to burn, should be taken out of the sick-room. Articles or furtinure that have already been exposed to infection should not be removed unless these have been disinfected. The room should be fully ventilated. Ten per cent. solution of formalin may with advantage be kept in the room in a vessel.

4. *Care of Convalescents.*—No person recovering from small-pox should be allowed to go out and receive visitors until every scab, crust and scale has disappeared, and there is no sore on the body. The hair should be carefully brushed to remove all particles adhering to the scalp and the whole body should then be thoroughly washed with soap and water. The convalescent may have a bath with some antiseptic lotion, and clothing previously worn should be thoroughly disinfected.

5. *Care of Corpses.*—All persons dead of small-pox should be wrapped in sheets soaked in a 40 p.c. solution of formalin and should be cremated or burnt with as little delay as possible. When coffins are used they should be air-tight.

6. *Disinfection.*—The infected house and its contents should undergo a most thorough disinfection with formaldehyde (*see* p. 435). All articles of clothing, bedding, etc., should be kept exposed to the sunlight. Rooms, offices, boats, vehicles, etc., which may have incidentally been exposed to infection should be washed with soap and hot water and then disinfected with 10 p.c. solution of formalin, or fumigated with formaldehyde or sulphur vapour.

As the nose and throat are liable to harbour the specific cause of small-pox, they should as far as possible, be cleansed, and gargled with some disinfectant.

7. *Personal Protection.*—Besides being vaccinated physicians and nurses when visiting a small-pox patient should wear a long overall fitting close along the wrist and neck. Failing this they should have a change of clothing. These garments should be immediately removed and placed in an air-tight receptacle and disinfected with formalin vapour. The hands should be thoroughly washed with soap and water and then again washed in some strong antiseptic solution.

Preparation of Calf Vaccine Lymph

The vaccine pulp consists of the entire vesicle and its contents, formed by the epithelium, leucocytes, products of inflammatory reaction, the fluid content of the vaccine, debris, etc. The real active principle of the vaccine virus is contained in the epithelial cells, the serous fluid which contains the lymph only does not contain it. The pulp is therefore used in the preparation of vaccine lymph.

Preparation of Calf.—The calf is kept in quarantine for a week to see that it is healthy. If so, it is strapped on a table and the lower part of the abdomen is carefully shaved. The shaved area is first washed with a 5 per cent. solution of carbolic acid and then well syringed with clean filtered water and finally cleansed with sterilised water. The wetted area is dried by means of sterilised gauze sponges.

Vaccination of Calf.—The calf is then vaccinated with glycerinated calf lymph introduced into the skin through numerous parallel linear incisions made by a sterilised scalpel. The scalpel must be frequently dipped in the vaccinating fluid. As these incisions are made additional lymph is run in along the cut by the aid of a sterilised blunt instrument such as an ivory spatula. It is necessary to inoculate the incisions immediately they are made otherwise the lips of

the wound are apt to swell and close the opening. After the vaccination, the shaved surface should be covered with a sterilised apron and the calf can then be removed to the stable.

Collection of Vaccine Material.—After 120 hours (five days) the calf is placed on the table and the vaccinated surface is carefully but thoroughly washed with soap and warm water. This may be done either by the clean hands of the operator or with absorbent cotton-wool. It is next washed with filtered water and finally with sterilised water. Excess of moisture on the surface may be absorbed by means of sterilised gauze sponges. The skin is then put on the stretch and the crusts and vesicles are collected with a sterilised Volkmann's spoon Each line must be taken in turn and must only be scraped once. In this way the vesicular pulp is obtained without admixture of blood. The pulp obtained is placed in a sterilised stoppered bottle of known weight. It is then carefully weighed. The abraded surface of the calf is then dusted over with starch and boracic acid powder.

Glycerination of the Vaccine Material.—The lymph pulp is next transferred to a triturating machine—all parts of which should have been previously sterilised by prolonged steaming. The pulp is passed through the machine and thoroughly triturated. To test its complete trituration a loopful of the ground-up material is suspended in a watch-glass of distilled water. If the trituration is complete no particles will be visible and the water will be made merely cloudy.

The pulp is now passed through the machine a second time together with 3 or 4 times its weight of sterilised mixture of 50 per cent. glycerin in distilled water. This mixture of pulp and glycerin water is then once more passed through the machine, thus producing a fine and intimate emulsion. Before preparing to store the emulsion a loopful of it should be taken with a sterilised platinum needle and agar-plates inoculated with it.

Storage of Emulsion.—The emulsion in the machine is received into sterilised glass test-tubes of a size that can be filled as completely as possible so that very little air remains in contact with the emulsion. Each tube is plugged with a sterilised cork, sealed with melted paraffin wax, and is then placed in a dark cool cupboard or ice chest. Each tube should be marked with the number of the calf and the date of the preparation.

The Issue of Lymph in Capillary Tubes.—The emulsion may be tested on agar-plates after a month, and if no growth is shown the lymph may be drawn into sterilised capillary tubes and used for vaccination purposes. If growths take place the lymph must be kept for a longer period until it ceases to cause growths. The capillary tubes should be sealed in a flame immediately after they are filled. If the special bottle for filling by means of compressed air be used it must be sterilised beforehand. Metallic collapsible tubes having a capacity to hold 25 to 50 grains are also used for issuing lymph, but these should first be properly cleaned and sterilised and after filling corked and capped properly to prevent leakage.

General Instruction.—The use of unripe lymph, that is, lymph containing contaminating microbes, is followed by fever, inflammation, and perhaps pus production. The use of stale lymph, generally so after eight months, on the other hand, simply results in more or less failure.

If stored in the cold, the lymph retains its activity for a much longer period. During the cold weather in Bengal the lymph when taken out of the ice chamber usually keeps well for about 10 to 14 days, but in summer it deteriorates in 4 or 5 days.

For every operation the vaccinator must thoroughly cleanse his hands, first with strong soap and warm water, then with a 5 per cent. solution of carbolic acid, and finally with sterilised plain water; and no assistant must be allowed to touch the vaccinated surface of the

calf's stomach before the lymph is taken nor any of the instruments, tubes, sponges, etc., unless with the same precautions.

All glasses, tubes, instruments, gauze, sponges, etc., must be completely sterilised before use, and the operator must himself see that the articles to be used are thoroughly sterilised.

Instead of glycerin the pulp may also the mixed with dehydrated and neutral lanoline in the proportion of one part of the pulp to two of lanoline (by weight). and then stored in sterilised tubes. One grain of this vaccine lymph is necessary for vaccinating three persons. The glycerinated lymph is preferred to the lanolinated variety, and is probably safer from chance of sepsis, but it has the disadvantage of being weak.

The lymph deteriorates on coming in contact with heat or even a weak antiseptic. The lancet, therefore, if sterilised by passing through a flame, should be allowed to cool down, and the area, thoroughly flushed with clean sterile water and then carefully wiped dry before performing the operation.

Summary of Measures for Dealing with Outbreaks of Small-pox

(1) Every effort should be made to find the source of infection and to prevent the spread of the disease.

(2) As soon as a case of small-pox has been reported the movements of the patient during the preceding two weeks should be ascertained, and all persons who have been in contact with him since the illness must be vaccinated or re-vaccinated.

(3) The most difficultper sons to deal with are the ignorant labourers, who disperse in all directions, and in this way carry the infection to other centres.

(4) Where special hospitals exist every endeavour should be made to induce such cases to go into a hospital. If they cannot be segregated in this way, they should, as far as possible, be isolated in their own houses.

(5) Contacts should be kept under observation for at least two weeks.

(6) Other steps include free vaccination throughout the locality. This may be done by empowering every medical practitioner to vaccinate all persons who apply to him. The local authority may supply lymph to the practitioners free of charge.

(7) In extreme cases, employ an army of assistants to go from door to door for the purpose of persuading people to be vaccinated. Female vaccinators will often be found to be of service for vaccinating women and young children.

Chicken-pox or Varicella

Chicken-pox is a contagious disease occurring in children mostly in an epidemic form. It very often coincides with epidemics of small-pox, but the mortality is practically nil.

Etiology.—There is no doubt that it spreads by a contagium from a previous case of the disease. Personal contact

or fomites very often convey the contagium but no specific organism has been isolated. The *incubation period* is about fourteen days and the patient should be isolated until the last scab has fallen off.

Chicken-pox and small-pox are separate and distinct diseases and an attack of one does not give protection against an attack of the other. Vaccination gives no protection against chicken-pox. The following scheme presents in contrast the salient features of variola versus varicella.

SMALL-POX	CHICKEN-POX
Prodromata severe	Prodromata slight or absent.
Heavy sickness, severe pain in back, vomiting.	Perhaps slight headache, pain in back, shivering,
Spots come out on third day. Spots come out in progressive order from above downwards- face, hands and arms, trunk, legs, feet.	Spots come out on first day. Spots come out in successive crops, the new spots being widely distributed.
Temperature; three days pyrexia at onset, and pyrexia again when suppuration occurs about the ninth day (called the secondary or suppurative fever).	Temperature not high as a rule. But pyrexia accompanies each fresh crop of spots if the eruption is profuse.
The pock comes up from below and is more sunk into the skin.	The pock superficial and is on the skin rather than in it.
Rash centrifugal.	Rash centripetal.
Spots more abundant on the face, back, shoulders and chest than on abdomen and loins.	Spots increase from extremities to the trunk. Distribution as copious on the chest, area for area, as on the face.
Liable to have very severe complications and sequelæ.	Neither complications nor sequelæ to be reckoned with, as a rule.
The centre of the vesicle is depressed.	The centre of the vesicle is the highest point.
Eruption apt to leave pits, often deep and permanent.	Pitting occasional and slight as a rule.

Prevention.—All cases should be reported to the Health Officer, as very often a mild case of small-pox may be mistaken for chicken-pox and thus escape control. It may prevail in an epidemic form, and although not as a rule fatal may give rise to much trouble, especially in schools, boarding-houses, jails, hospitals, etc. The patient should always be isolated with a special nurse. The measures taken to prevent the spread of small-pox are also applicable to chicken-pox. After separation of all the crusts the patient should have a warm bath and complete change of clothes before regaining perfect freedom. The room should be thoroughly washed and cleaned, and all clothes, bedding, etc., used by the patient subjected to a thorough disinfection either by steam or boiling.

The serum obtained from convalescent patients within a month after the appearance of the rash has been found to have a prophylactic effect; 10 c.c. of the serum being given at an injection. This serum however is inferior to convalescent measles serum.

MEASLES

Measles is a specific infectious fever characterised by macular eruptions and widespread catarrh affecting chiefly the respiratory, nasal, and ocular mucous membranes. It occurs generally in an epidemic form and is infective from the very beginning. Its distribution is universal, and the disease is independent of climatic influences. Children under the age of five are mostly affected, and the mortality is greater among males than females, especially among children under two years of age. The death-rate is higher among the poor and in overcrowded localities.

The *incubation period* is fairly constant and is ten to eleven days in most cases, although it may be as short as six and as long as fifteen days. A true relapse is rare, although second attacks are not very uncommon.

Etiology.—The specific cause is unknown, although experiments on monkeys have demonstrated that the virus is filtrable through porcelain bougies capable of holding back all known bacteria. The infectivity is probably lost by the time convalescence is reached. The nasal and bronchial secretions seem to carry the virus, the scales having been found non-pathogenic for monkeys even at the height of the disease. Direct contact with a previous case of measles is the most important factor in the spread of the disease. Its propagation may be effected indirectly through the agency of infected articles. The infection may be given off by the breath and mucus. The poison is also diffused through the medium of air and infection probably occurs by inhalation. Hektoen, experimenting on human beings, has shown that the cause of measles is present in the nasal secretions, scrapings of the skin, and the blood of patients during the earlier part of the eruptive stage.

It is highly contagious in the pre-eruptive stage, and since the nature of the disease is not recognized at this period, most damage is then done.

Quarantine.—For contacts eighteen days, for the sick until desquamation and subsidence of the catarrhal condition are complete.

Prevention.—This is the most difficult disease to handle, since the long period of incubation and the four days of infectiveness before the appearance of the rash render its control almost impossible. The suspicious cases should be early isolated without waiting for the rash to appear. Infected clothes, bed-room, etc., should be properly disinfected.

Application of carbolised oil or glycerin prevents the infection from being carried about by the air.

Immunity can be conferred by injecting blood serum of patients convalescent from measles within three days of contact or exposure to infection. It is a valuable method of preventing or attenuating an attack both in infants and older children. A successful attempt was made at the Paris Foundling Hospital to attenuate the disease by injection of convalescent serum before or during the seven or nine days after exposure. When the injection was given later, even after the period of invasion, the attenuation was less definite. The severity or fatality was much higher amongst those who did not receive any serum.

The following measures exercise considerable control over the spread of the disease :—

1. Compulsory notification.

2. Prompt notification to the sanitary authority by the schoolmaster of the occurrence of any case amongst the scholars, and by the sanitary authority to the schoolmaster of any case occurring in the homes of any of the scholars.

3. In case of any exceptional prevalence the school should be closed.

4. Removal to hospital of the earlier cases.

TUBERCULOSIS

Tuberculosis is an infectious disease, usually chronic in nature and is caused by the tubercle bacillus, an organism discovered by Koch in 1882. It attacks various organs and tissues ; its usual manifestations being pulmonary phthisis, scrofula, lupus, tabes mesenterica and meningitis. Man and most domesticated animals are susceptible to tuberculosis.

The disease is prevalent in all countries and climates. It is more prevalent in crowded localities like cities and towns, and particularly in the slums than in the villages, and less in the drier and cooler uplands than in the warm and humid lowlands and towns on the coast. The dryness and purity of the air have apparently a decided effect on the incidence of the disease and its mortality.

In the British Army in India the death rate from tuberculosis is 0.17 per 1000, in the Indian Army 0.52 per 1000, and in the jails 3.21 per 1000. The mortality from tuberculosis has been steadily rising in India especially in the cities and towns, due to a combination of causes, mostly social and economic. In the city of Calcutta there were 2120 deaths from tuberculosis in 1920, 2208 in 1924, 2662 in 1931, 2280 in 1932, and 2595 in 1933. In 1927, 7689 deaths were registered in Bengal as against 7032 in 1926, 11,801 in 1932 and 14,802 in 1933. The death-rate in the urban areas of Bengal is about 13 times that in the rural areas. In Peshawar

city out of 75,000 persons examined in 1927, 3000 were detected as suffering from active tuberculosis.

No race is exempt from the disease but the coloured races are considered to be more susceptible than the whites. Both sexes are more or less equally liable to the disease, but the incidence and mortality between the ages of 15 and 35 is much higher in females than in males, that being the child bearing period during which the vulnerability to the disease is decidedly higher.

The main factors concerned in the prevalence of the disease are defective social and economic conditions, bad housing, poverty, malnutrition, early marriage and motherhood, frequent pregnancies and childbirths, indiscriminate spitting, the purdah system which prevents females from having fresh air and sunlight, and want of knowledge especially on the causation and prevention of the disease.

The mortality from tuberculosis is comparatively high during the first two years of life and decreases from the 2nd to the 12th year, after which it shows a marked increase, being greatest between the 15th and 25th year. After 35 tuberculosis mortality shows a decline. With the advance in sanitation and public health together with an improvement in social and economic conditions and the nutrition of the masses, tuberculosis is diminishing in the modern countries of Europe and America, whilst it is increasing in India and other Asiatic countries where commencing urbanization and industrialization have produced a detrimental effect on social conditions and bodily nutrition.

Tuberculosis is not a hereditary disease in the sense that it is transmitted from the parents to the offspring (*see* page 306). It is possible that the tissues of the child may inherit susceptibility to the disease, but the predominant factor in family infection is the close association with the infected parents or other members of the family and the presence of the nutritional conditions common to the family as a result of identical social, dietetic and economic factors governing the whole household.

Etiology.—The bacillus of tuberculosis is a non-motile minute rod, 2.5μ to 3.5μ in length and 0.3μ in thickness, i.e., in proportion to its length it is a slender organism. Longer forms of 5μ and above are also occasionally met with. It is an acid fast organism staining by the Ziehl Nelsen method and has a beaded appearance when stained, clear spots alternating with stained parts in the body of the bacillus. The bacilli are usually straight but often curved. They are aerobic and retain their vitality for a long time outside the body. They thrive at an optimum temperature of about 37°C. Though they can live in the dry state for weeks and even months they are quickly destroyed by boiling or by exposure to sunlight, offering some resistance to weak germicides.

Koch maintained that the organisms of human tuberculosis was different from the bovine and that each of the two types of germs was not transmissible to the other host. He argued that bovine tuberculosis is not dangerous to man and the milk of tuberculous cows was not infectious to man. This view has been disproved and the report of the Royal Commission on Tuberculosis (1907) laid down as follows:—

"There can be no doubt but that in a certain number of cases the tuberculosis occurring in the human subject especially in children is the direct result of the introduction into the human body of the bacillus of bovine tuberculosis, and there also can be no doubt that in the majority at least of these cases the bacillus is introduced through cow's milk. Cow's milk containing bovine tubercle bacilli is clearly a cause of tuberculosis and of fatal tuberculosis in man".

The mutability of the human bacillus into the bovine and vice versa as a result of long residence in the tissues of the host of the other species is a question still remaining unsolved. Whether the bovine bacillus becomes transmuted into the human either by prolonged multiplication in the human subject or by a series of passages in human beings has to be decided by patient and careful observation and enquiry.

Modes of Infection.—1. *Inoculation.*—There is no evidence to show that tubercle bacilli can pass through the unabraded skin, but instances are known amongst butchers and surgeons of infection through cuts and wounds. The so-called butchers' wart is a tuberculide and infection along the lymphatics of the arm into the glands at the elbow and the axilla have been known amongst surgeons. Tubercle bacilli can however pass through the unbroken mucous membranes.

2 *Inhalation.*—The bacilli leave the human body mainly in the sputum and from the point of view of prevention, the expectoration should be regarded as the greatest and the most common source of danger. The bacilli leave the body through other discharges as well. The fæces and the urine in cases of intestinal and genito-urinary tuberculosis and the discharges from cold abscesses, caseating glands and suppurating joints in tuberculosis of the respective tissues also contain bacilli and may carry infection.

Dried sputum on roads, floors, walls, clothing, bedding, handkerchiefs, etc., carried about in the air in the form of dust constitutes a fertile source of infection. The chances of infection increase in proportion to the want of care in the disposal of discharges and the absence of sunlight to kill the organisms. Cornet and others have demonstrated the presence of living bacilli in the dust and furniture of rooms where tuberculous patients lived weeks or months previously and no disinfection was carried out after the patient vacated

or died. The risks of infection in open places are practically negligible as sunlight has a bactericidal action on the organisms, especially in a hot tropical country like India. The organisms do however remain alive and active for long in dark, ill-ventilated and moist places, as in the slums and habitations of the poorer classes.

Another method of inhalation infection is when a tuberculous patient speaks, coughs or sneezes, allowing the contents of the mouth or respiratory passages to be sprayed into the air and inhaled by others in minute particles or droplets containing virulent bacilli. This kind of "droplet infection" is especially dangerous in ill-ventilated rooms where the patient coughs or sneezes in the proximity of others.

3. *Ingestion.*—Bacilli can gain entrance by the alimentary canal as in the case of children handled and fed by tuberculous mothers or servants. Tubercle bacilli gaining entrance through the food or drink, as by the use of cups, spoons, saucers, and utensils used by consumptives are ultimately absorbed through the intestinal lymphatics and thoracic duct into the blood stream producing lesions in distant parts of the body especially the lungs, leaving little or no lesion in their passage. Infection through cow's milk is common in Europe and America, but is apparently rather rare in India, as bovine tuberculosis seems to be comparatively uncommon. It is not unlikely, however, that with the development of dairy farms, bovine tuberculosis may become more prevalent in India in the future and bovine infection amongst human beings become more frequent. Infected meat may similarly become a more common cause of ingestion infection than at present. By ordinary cooking, meat contaminated at the surface alone loses its harmful quality, but meat affected with tubercle at its depth may still retain infectivity. Similarly thorough boiling of milk can sterilise it of its tuberculous infection, but insufficient heating cannot remove the infection from it entirely.

Too much stress has perhaps been laid on the inhalation factor in tuberculous infection and the fact that pulmonary tuberculosis constitutes the predominant manifestation of tuberculous disease has been adduced as an argument in favour of it. It must, however, be understood that the particles of dust and organisms inhaled are mostly trapped by the mucous membrane of the nose, nasopharynx and pharynx, and ultimately ingested by the alimentary tract, comparatively few organisms perhaps entering the pulmonary bronchial tract. Whatever may be the method of infection the bacillus of tuberculosis has a tendency to affect the lung ultimately, as the seat of election of the disease. *Malnutrition* is perhaps the most important factor in the causation of tuberculosis, impure air, overcrowding, dampness of soil and defective ventilation and sunlight being subsidiary factors leading to

malnutrition. A defective and ill-balanced diet is perhaps the one factor which above all others renders the body a suitable soil for the growth of the bacilli of tuberculosis which find it difficult to grow in a healthy and soundly nourished body. Hence the truth of the now well-recognized fact that the "soil", *i.e.*, the body is more important than the "seed," *i.e.*, the bacillus of tuberculosis plays a minor part in the causation of the disease, unlike the other infectious diseases like enteric, diphtheria, cholera, etc., where the seed is the more important factor than the soil. Deficiency of vitamins A and D and of proteins in general in the food predisposes to tuberculosis and this is what necessarily happens amongst the poor who cannot afford milk, meat and other foodstuffs that are essential for sound nutrition and have to live in bustees or slums in ill-ventilated, back to back houses with poor conservancy, sanitation and drainage. Adenoids and enlarged tonsils are on the one hand the signs of malnutrition and on the other the causes of deficient aeration in the lungs and disturbed metabolism and nutrition. They are therefore common precursors of tuberculosis.

Tuberculous Infection, Morbidity and Mortality.—The vast majority of human beings in all civilised countries imbibe tubercle bacilli at some time or another after birth, the new born baby being free from infection. It has been estimated and demonstrated by the Von Pirquet and Mantoux tuberculin tests that by adult age 60 to 95 p.c. persons have imbibed the infection, but it is only about 1 to 3 p.c. that show the signs of active tuberculosis at any time, of whom about one-tenth die annually from the disease. In other words the infection rate of tuberculosis is about 600 to 950 per mille, the morbidity rate 10 to 30 or more per mille and the mortality rate 1 to 3 or more per mille per annum; the variations depending on the country and the locality. In Great Britain, America, and Australia tuberculosis mortality is less than 1 per 1000; in India it is perhaps 3 per 1000 and in the Indian cities it is probably even higher.

Prevention.—For the production of tuberculosis two factors are essential, a susceptible body and the tubercle bacillus. The seed, *viz.* the tubercle bacillus can take root only in a soil suitable for its growth. *viz.* a body weakened by malnutrition. In fact in a disease like tuberculosis, unlike most other infectious diseases, the causative organism plays a comparatively unimportant part and general nutrition is the predominant factor in controlling the prevalence of the disease. The fact that the disease is more prevalent in a hot and sunny country like India than in countries like Great Britain, where sunshine is somewhat of a luxury, indicates that sunshine with its antiseptic effect is a minor factor. The general prevention of tuberculosis may be classified under the following heads:—

A. Public Measures.—1. Improvement of the general sanitation leading to improvement of the general health of the people is no doubt an important measure of prevention.

2. Every facility should be given for early diagnosis of the disease, because tuberculosis is one of the most curable of diseases if dealt with in its early stage. The early diagnosis of tuberculosis can be effected by the opening of Tuberculosis Clinics at all important centres, if possible at every district head quarters.

3. By sanitary town planning, *i.e.*, by the demolition of slums and the establishment of Improvement Trusts for the residence of the poor, with sufficient ventilation and air space.

4. The provision of open spaces, parks and play grounds in and near all towns and cities wherein the public and especially the children can have plenty of open air recreation and exercise.

5. Medical inspection of schools for ensuring proper ventilation and working hours, and for the proper supervision of the general health of the children.

6. The institution of maternal and child welfare centres all over the country to improve the nutrition of the newborn and growing child and the health of the mother.

7. Medical inspection of factories and workhouses to ensure proper ventilation and the control of the hours of work of the operatives.

8. The development of agriculture and industries including the rearing of cattle for a proper supply of food and milk.

9. The prevention of early marriage and early motherhood by the legal prohibition of early marriage, as by the Sarda Act.

10. The general and health education of the masses by propaganda work and by the establishment of tuberculosis hospitals, sanatoria, etc., which afford practical education in the prevention of the disease.

11. The penalisation of spitting, especially in public places and conveyances like buses, trams, etc., and by the provision of cuspidors or receptacles for sputa in public places.

12. The affording of facilities for segregation, especially of the advanced cases, in hospitals.

13. By the inspection of meat and milk and by a thorough supervision of slaughter houses and dairies.

14. By the provision in asylums, jails and other large institutions for the treatment of cases of tuberculosis in separate and suitable wards.

There are at present several tuberculosis dispensaries, hospitals and sanatoria in India, and the King George V Thanksgiving Anti-tuberculosis Fund is not only encouraging the specialisation of medical men in tuberculosis, but educating the masses by lectures, literature and demonstra-

tions on the causation and prevention of tuberculosis. By combining such health propaganda work with improvement in general sanitation and by improving the nutrition of the masses, countries in America and Europe have succeeded in lessening their tuberculosis mortality by 75 to 90 per cent. during the last 75 years. It will no doubt take India a similar length of time to control the disease, which at present is on the increase in the country.

B. *Private Measures.*—1. The importance of light and air in all living and bed rooms should be inculcated on the people and the false fear that a "cold" in the chest is caught by keeping all the windows and doors open at night should be corrected. All living and bed rooms should be freely exposed to light and sun as long as possible.

2. There is perhaps no more important factor in the prevention of tuberculosis than sound nutrition. A suitable proportion of proteins with vitamins in the diet is the most valuable of preventives of tuberculosis. There is no doubt that rice is a very poor article of diet unless supplemented freely with meat, milk, *dal*, wheat and ragi along with green vegetables and fruits. The high incidence of tuberculosis in Madras, Bengal and other parts of India is most likely due to rice constituting the main article of diet. Vitamins A and D are more important than the other vitamins in the prevention of the disease, therefore milk, egg, butter, fresh meat and fish must constitute a suitable part of the diet. For vegetarians wheat, *dal*, ragi, milk, dahi and butter with green vegetables and fruits with the minimum of rice should be advised.

Nasopharyngeal affections in children, like enlarged tonsils and adenoids should be promptly dealt with and breathing exercises should be encouraged to develop the chest. The mouth and teeth should be attended to, a foul mouth and carious teeth being often the fore-runners of tuberculous infection.

The consumptive should not be allowed to share a room and certainly not the same bed with another. The marriage of a tuberculous person should be put off for about 2 years after the arrest of the condition. The tuberculous mother especially when she has open tuberculosis of the lung should not nurse or handle her child which should be segregated from her and nursed and brought up by a healthy woman or wet nurse. A patient suffering from consumption must be taught all precautions in detail regarding prevention of infection to others. He should also be advised not to swallow his sputum lest the intestines should become affected. A tuberculous person should change his work into an outdoor, open air work whenever possible, even if it may mean some loss of income.

The consumptive must be made to spit into a vessel con-

taining a disinfectant and the vessel should be daily sterilised by thorough boiling. Flies should be prevented from getting at the expectoration by using spittoons with covers and the expectoration should be disposed of by being poured into the underground drains or by being burnt or deeply buried. The disinfection of rooms used by consumptives by wet mopping or flushing is an important preventive measure. Dry sweeping should be strictly prohibited in such rooms. Careful microscopic examination of sputa of persons suffering from chronic coughs constitutes an essential measure not only for the detection of the disease but for the adoption of disinfection and preventive measures.

Mumps

Infectious Parotitis

It is an infectious disease characterised by swelling of the salivary glands, specially the parotid, and occurring during childhood and adolescence.

Etiology.—It is common in all parts of the globe and occurs endemically in large centres of population, especially in schools, boarding houses, barracks, etc. Although no age is entirely immune it is common in children and cases of transmission to the fœtus *in utero* have been recorded.

It sometimes occurs associated with other diseases as complication, *e.g.* in measles and typhoid fever.

The causal organism has not yet been positively identified, but the virus is a filter-passer and is contained in the saliva whence it enters the salivary glands through Wharton's duct. Infection is conveyed direct from patient to patient through droplets; although it is possible to be conveyed by apparently healthy intermediaries, or fomites.

Orchitis is a common complication in males, though ovaritis or mastitis may also occur in females.

Prevention.—The incubation period is long (17 to 20 days) therefore quarantine is rather irksome. The patients should be isolated, and the contacts, unless they suffered from the attack before, should also be isolated. The disease is infectious two or three days before the swelling appears, and isolation should be three weeks from the enlargement of the gland up to one week after the subsidence of the glandular enlargement.

Cerebrospinal Fever

It is a specific disease occurring in an epidemic or sporadic form and characterised by fever, headache, and symptoms of meningitis due to invasion of the body with *meningococcus*.

Epidemiology.—Within recent years several epidemics occurred in India, first in 1918 and then in 1932 and 1934.

These were confined to Bengal, Central India, Bombay, Karachi and Northern India. A peculiar feature of these epidemics was that the attacks were mainly confined to persons between the ages of 15 to 55 years; only a few children being affected; whereas in European epidemics children and adolescents were largely attacked. In the spring of 1932, 22 cases with 11 deaths occurred in the Borstal Institution, Lahore. During the period from 1st March 1933 to 1st April 1934, 636 cases were admitted in a hospital in Calcutta. Since 1930, Cairo as well as other towns in Egypt suffered from a severe epidemic with an explosive attack in February 1932, and a decline in incidence in 1933. The highest prevalence had been in the months of February to April. Although all the religious bodies and nationalities were attacked, the incidence and fatalities were highest among the jews.

Unlike other epidemic diseases it has certain characteristic features of its own, *viz.*, the small percentage of people attacked; the erratic nature of the outbreaks; relative escape from the epidemic of certain localities close to the infective areas; occurrence, as a rule, of not more than one case in a house or an institution; and the difficulty in tracing any relationship between one epidemic and another. The disease does not appear to be very contagious and rarely any nurse or attendant get the infection. Much light has however been thrown by the recognition of the existence of "carriers" which supplied the solution to much of the epidemiological problems.

Etiology.—The specific organism is *Diplococcus meningitidis intracellularis* of Weichselbaum, and is found in the cerebrospinal fluid and also in the naso-pharynx of 'carriers'. It is gram-negative in staining character. Infection generally takes place by the buccal and nasal sprays; while overcrowding helps transmission of the organisms by *droplet infection.*

It may be regarded as a weather disease fostered by damp, muggy and humid climatic conditions which lead to excessive indoor humidity. It has been suggested that saturation of the air with watery vapour is a predisposing factor and that in conditions of great humidity the naso-pharyngeal mucosa become more spongy and permeable and thus allow the passage of the specific organisms. Direct contagion though possible is rare.

Prevention.—With our present knowledge regarding the causation of the disease no specific prophylactic is available. Efforts should be made to prevent overcrowding and ensure proper ventilation and sufficient sunlight in the rooms. The contacts should be segregated and steps taken to reduce the number of 'carriers'. Although healthy carriers are more responsible for the spread of the disease, it is nevertheless imperative that every case should be isolated so as to prevent

any contact with healthy persons. This is best accomplished by segregating the patient in a hospital. Swabs of the nasopharynx of all contacts should be taken and bacteriologically examined. Since the organism is usually found in the nasopharynx, antiseptic gargles have been used, but their value is hypothetical. During the war, exposure for a few minutes to the vapour of chloramin T in a special chamber was found quite efficacious. Other measures are the same as described under influenza.

Influenza

Influenza is an acute specific infectious disease characterised by fever, with symptoms affecting mainly the respiratory, digestive, and nervous systems, and by severe prostration.

History.—Every quarter of the globe has been the scene of visitations of epidemic influenza. The first appearance of the disease in Spain caused it to be known as "Spanish influenza" in contrast with the "Russian influenza" of previous epidemics. During 1918 an exceptionally widespread epidemic appeared, which affected the inhabitants of practically every Continent. This epidemic not only caused directly or indirectly, a very large number of deaths which in India alone were computed to exceed five millions, but left behind it a legacy of minor ailments with consequent widespread debility.

Etiology.—The organism responsible for the epidemic of influenza has not been definitely identified. The weight of evidence still points, however, to the bacillus, called the *bacillus of Pfeiffer* being the cause; at all events it is intimately associated with the disease. Judging from clinical and epidemiological standpoints, the disease which appeared in India was identical with the last great pandemic of influenza which occurred in 1890-91. Pfeiffer's bacillus, pneumococcus and streptococcus, seem to be responsible for most of the fatal complications of influenza.

Influenza is a disease which exhibits an intense infectivity, and an incubation period which is relatively very short, *i.e.*, from 6 to 48 hours. It is commonly believed that the disease is spread by the infected secretions of the throat and nose of infected persons finding lodgment in the nose and throat of uninfected people. The commonest means by which this occurs is by coughing and sneezing, especially in confined spaces.

Prevention.—A. *Education of the Public with regard to the following*:—

1. Avoid infection as much as possible.
2. Cultivate healthy and regular habits, take regular exercise, eat good food, and avoid fatigue, chill and alcohol.
3. It is most infectious in the earliest stages; and coughing, sneezing, spitting and hawking in public places are dangerous.

4. It is not always possible to avoid infection, but the risk can be lessened by

(*a*) working and sleeping in well-ventilated rooms;

(*b*) avoiding crowded gatherings and close, ill-ventilated buildings or carriages; and wearing warm clothing.

5. Those attacked should

(*a*) either go to a hospital, or go to bed and keep warm

(*b*) occupy, if possible, a separate bedroom;

(*c*) not return to work until convalescence is well established, and during convalescence be extremely careful to avoid chill which may induce a relapse or complications;

(*d*) avoid meetings and places of entertainment for at least one week after the temperature has become normal.

B. *The Closing of Schools, etc.*—As regards closing of schools it should be remembered that if children were taken from well-ventilated schools they might add to the congestion of already overcrowded houses. This matter must be left to individual localities to settle, bearing in mind that it is necessary to limit the number of unnecessary gatherings and that it is necessary to keep up the morale of the public. In this connection attention should be drawn to the dangers associated with travelling in cars and public conveyances. It is believed that a fertile source of the spread of infection lies in overcrowded railway carriages, tram cars, etc., therefore prevention of overcrowding should be specially insisted on.

C. *The Wearing of Face Masks.*—Opinions are divided as to the efficacy of this measure; it largely depends upon their construction. The masks should be of very close woven muslin or gauze. Recent work in America would seem to point to a gauze with a mesh 44 by 40 to the inch; three to six layers of fine muslin should form the mask and they should be applied so as to cover the nose and mouth completely. The gauze is cut 8 inches wide and 23 inches long.

The use of these masks should be made compulsory among nurses and attendants in hospitals which admit influenza patients, and might be adopted in houses where cases of influenza are present, and among volunteers and others who come in contact with the sick.

D. *Isolation.*—Insistence upon isolation of influenza cases in India is impossible. Every case, however, of influenzal pneumonia should be rigorously isolated.

E. *Sprays and Gargles.*—The use of disinfectant sprays and gargles is not recommended. Disinfectants are apt to remove the protective mucus of the throat and mouth, and to cause irritation of the mucous membrane or lining membrane of these cavities, and so predispose to the lodgment of infective material. They can hardly be used strong enough to be protective without causing violent irritation.

F. *Disinfection.*—With regard to the disinfection of

infected rooms, it is now fairly established that ordinary cleansing with water, airing and sunning effect as much good as the use of actual disinfectants. All handkerchiefs, sheets and clothings, recently soiled (within 48 hours, as drying kills the infective agent) should be boiled or otherwise sterilised.

The periodic disinfection on the above lines of public places, *e.g.*, railway waiting-rooms, trams, rolling-stock, dak-bungalows, *serais*, etc., which in epidemic times, may be taken to be infected, is also strongly recommended.

G. *Quarantine.*—A limited measure might be practised by local institutions, such as resident colleges, schools, asylums and jails.

H. *Prophylactic Vaccination.*—A mixed vaccine of the following composition and doses was recommended by the War Office Committee :—

	First dose	*Second dose*
B. influenzæ	30 millions	60 millions
Pneumococcus	100 ,,	200 ,,
Streptococcus	40 ,,	80 ,,

Certain Non-communicable Diseases of Doubtful Etiology

Beri-beri and Epidemic Dropsy

Beri-beri is a specific form of multiple peripheral neuritis characterised by special liability to the implication of the pneumogastric nerves, gastro-intestinal disturbances of varying severity, and a liability to œdema of the connective tissues and to effusion in the serous cavities. The name is probably derived from the Singalese word "beri" meaning weakness; beri-beri signifying great weakness. It occurs endemically, or as an epidemic in tropical and sub-tropical countries, ships, asylums, etc.

Distribution.—It is endemic in the Far East and is a scourge in Malaya and the Eastern Archipelago. It is common in China, Japan, Ceylon, India, Burma and the Philippines, and also amongst the Chinese wherever they live in large numbers. The Chinese of Calcutta are equally liable to this disease. In short the disease prevails wherever man eats polished rice.

Etiology.—Beri-beri attacks both sexes and is rare in the two extremes of life. It affects both the rich and the poor—the former being more commonly attacked. It is common in prisons, asylums, and such other places where people are confined indoors. In the Malay States it is very prevalent amongst the miners. Although epidemics may occur at any time of the year, it is very common during the hot and damp season, and in places where the temperature is hot all the year round it may appear at any time. The incidence of the

disease is greatest amongst those whose diet chiefly consists of rice, although all rice-eating races are not affected.

Many theories have been put forward from time to time to explain the cause of beri-beri. These may be grouped under three heads, viz. (*a*) *deficiency* theory; (*b*) *intoxication* theory; and (*c*) *infection* theory. The first view is that the neuritis is due to deficiency of food or of certain known essential ingredients of food, *i.e.*, starvation or partial starvation. This view has been strongly advocated by some Japanese authorities, especially Takaki, who considers the essential cause of the disease to be insufficient nitrogenous food—"nitrogen starvation." The second is that some unknown essential for the proper nutrition of the nerve is absent from the dietary and that when this essential is withheld long enough nerve degeneration results. According to this hypothesis beri-beri is due to the absence of some essential in the food and which is absent when rice forms the main article of diet.

Braddon held that the disease was caused by the ingestion of toxins formed in over-milled rice by the action of micro-organisms. This view, however, was rejected in preference to the vitamin deficiency theory; although it should be noted that within recent years some poisonous substances were extracted by many workers from certain samples of rice producing the disease.

Wright regarded the neuritic element in the same relation to a primary bacterial lesion, in this case a gastro-duodenitis, that the neuritis in diphtheria has to the throat lesion of that disease. He regarded the disease as a toxi-infection caused by the absorption of toxins from the gastro-intestinal tract giving rise to toxic neuritis.

The observations of Fraser and Stanton go to prove that the neuritis in beri-beri is due to the deficiency of *vitamin B* which is removed during polishing of rice. It has been found that if a pigeon is fed on polished rice only it suffers from symptoms of beri-beri, *i.e.*, shows signs of neuritis, and loses weight, and if this diet is persisted in it dies with all the signs of multiple neuritis (*see* page 149). But if a small dose of vitamin B, or some of the polishings of the rice, *i.e.*, the dust or remains of the pericarp which has been removed in the process of milling, which contain vitamin B, be given, it will gradually lose the signs of neuritis, gain in weight and recover. Acting on these observations the use of white or polished rice in jails, asylums, schools and hospitals has been strictly forbidden in Singapur and other places with the result that beri-beri which hitherto had been the cause of enormous mortality has been practically banished from these institutions. McCarrison holds that although deficiency of vitamin B plays an important part in the causation of the disease,

there is some evidence that a toxin of metabolic origin is also responsible for the trouble.

Although deficiency of certain accessory food factors is the essential etiological agent in the genesis of beri-beri yet the infections and parasitic agencies cannot entirely be ignored. There are a number of cases which cannot be explained as being due to the absence of certain accessory food factors only, and without the possibility of infection their occurrence cannot be explained.

It is possible that the causes of beri-beri may be many, and that the cases of general neuritis at present included under this head are due to several factors, and should be subdivided accordingly, and that there is not one but many forms of nerve degeneration included under the term beri-beri. Thus the conditions giving rise to symptoms now classed under beri-beri are due to the following factors :—

1. Deficiency of vitamin B, and this may be classed as *deficiency beri-beri*.

2. Due to some form of intoxication associated with rice or other articles of diet : *intoxication beri-beri*.

3. Of doubtful etiology. It is possible that both the above factors are involved (Megaw).

The condition known as **epidemic dropsy** is considered by some as another phase of beri-beri. It, however, differs from beri-beri in many respects, and the writer as a result of careful observation of different epidemics believes that it is not caused by vitamin deficiency but a toxi-infection due to the formation of some toxin either in the rice or some other article of diet.

Epidemic dropsy is characterised by œdema and anæmia, and preceded in most cases by gastro-intestinal disturbances, fever, and irritation of the skin. It often occurs in an epidemic form, death being sudden, often due to œdema of the lungs and cardiac complications. The sudden onset of the disease and the gastro-intestinal symptoms which frequently precede the attacks are much more suggestive of intoxication than of a food deficiency. Moreover instances are not wanting when a healthy person shows definite symptoms of the disease within a few days of his arrival in the affected area and whose diet can in no way be considered deficient in any of the different accessory food factors.

The first systematic account of epidemic dropsy was given by Col. K. MacLeod, I.M.S., based on the disease which appeared in Calcutta in the cold weather of 1877-78, 1878-79 and 1879-80. It broke out in Shillong and Assam in 1878 and at Dacca in 1879. It was carried to Mauritius in the cold weather of 1878 where it prevailed until 1879. Lovell published an account of this disease as seen in Mauritius and claimed that it was not contagious.

Stray cases were reported in 1907 and 1908, and in 1909,

1926, 1927, 1930, 1931, 1932 and 1934 it occurred in an epidemic form in Calcutta and its suburbs. Greig showed that the incidence of epidemic dropsy coincided with periods of high food prices and famine conditions. He found no causative organisms in the fluids or tissues of the patients.

Etiology.—Both sexes are affected, though the incidence is greater among the females. The majority of cases occur between the ages of 20 and 40. Children and old people are less affected.

Race.—The Hindus, Mahommedans, and Indian Christians are all affected. It is comparatively less among Anglo-Indians and still less among Europeans.

The etiological factor of well-to-do Indians who prefer old stored rice led to an examination of stored polished rice and the discovery of the rice bacillus by Acton (Calcutta School of Tropical Medicine) which develops a toxin. This toxin is supposed to cause the disease.

Prevention.—Whatever may be the true cause of the disease certain preventive measures have already proved to be highly effective. As soon as the disease breaks out in institutions like asylums, jails and schools, the whole place if possible, or at least the infected quarters, should be vacated and not reoccupied till they have been thoroughly cleaned and disinfected. Thorough ventilation should be enforced and overcrowding as far as possible avoided. The ration should be revised and where rice is the staple food it should either be excluded or considerably reduced and substituted by meat, peas, beans, wheat and milk. Polished rice should be entirely stopped. In asylums or jails, where there is a possibility of its breaking out, the knee jerk should be tested and the legs examined for œdema and hypersensitiveness, and any suspicious cases isolated at once. Marmite or yeast extract, wheat atta and ground nut (arachis nut) are rich in antineuritic vitamin, and their use in the diet is not only an efficient prophylactic but a valuable remedy.

Summary of preventive measures :—

1. Rice should be stored only for a short time in well-ventilated and dry places. The old stock should not be mixed with the fresh one. In the form of paddy it can be kept for a long time without being infected.

2. If the disease appears, the supply of rice should be regarded as unfit for use. The store-house or other receptacles where the rice was kept should be considered as infected and likely to contaminate any fresh rice.

3. In an outbreak not only those affected, but also the people of the house should stop taking rice and take *whole wheat atta*.

4. Diets rich in vitamin B, *e.g.*, eggs, meat, *dal*, fresh vegetables are of special value.

5. The diet should be healthy and a sufficient supply of proteins, fats, vitamins and phosphorus is essential.

Diseases of Animals Conveyed to Man

Rabies

Rabies or hydrophobia is an acute, specific disease communicated from a rabid animal to a susceptible animal, usually through a wound produced by biting. It is however only in the case of man that the term "hydrophobia" should be applied as the fear for water is only observed in human beings.

Etiology.—Although all mammals are susceptible to rabies, it is generally contracted by man from some domestic animals, usually dog. Some of the worst cases of hydrophobia in India are due to the bites of mad jackals. The infection is usually conveyed through a bite ; but since the specific poison is contained in the saliva of animals suffering from the disease, infection may be conveyed by simple licking, should there be any sore or abrasion on the skin.

Rabies exists practically all over the world, but it has been stamped out by strict regulation in England and Germany. In India where every village is overrun by large numbers of unowned pariah dogs and where jackals abound, the question of reducing their number will be evident from the figures of the Pasteur Institute at Kasauli where 17,500 people were treated during the period 1902 to 1912, and of these about 15,000 cases were from bites by dogs, and 2500 by jackals ; the remaining cases being due to bites by horses, cats, cows, etc. In 1927 there were 2,342 recorded cases of deaths from rabies as against 2,278 in 1926. The Pasteur Institute of Calcutta at the School of Tropical Medicine treated 5,585 cases in 1925, and in 1935 no fewer than 10,426 persons attended the Institute. The above, however, is not by any means the exact figure showing the actual number of cases, as the poor and the uneducated hardly ever avail themselves of the Institute, but have recourse to local indigenous treatment.

The Virus.—The disease is due to a filtrable virus first described by Negri who believed it to be a protozoon parasite in a certain stage of its development. On the other hand others look upon them as degeneration products, the result of the disease or, at the most, comparable to other cell inclusions whose nature is uncertain, but which as a class, are not regarded as parasites.

Seat of Virus.—At the autopsy of the man or animal dead of rabies the poison is always found in the brain, medulla, cord, and the peripheral nerves. The virus is present in the salivary glands whence it passes to the saliva. The presence

of the virus in the saliva greatly depends on the site of the inoculation. If the dog is inoculated in the eye the saliva becomes virulent three days before the appearance of the actual symptoms of rabies. Once the symptoms have set in, the animal never lives longer than ten days.

Incubation Period.—This is extremely variable. The average period is as follows: Man, forty days; horse, twenty-eight to sixty days. In dogs the incubation period varies from 16 to 90 days, though the symptoms appear between the 25th to 55th day after the bite. It is therefore necessary to segregate the dog bitten by a rabid animal for at least three months and kept under observation for another three months. This is the practice followed in England.

The incubation period depends upon:—

1. Site of the wound.
2. Relation of the nerve.
3. Amount of the virulence of the virus.

It is probable that the long period of incubation is due in part to the fact that the living principle reaches the central nervous system, but remains dormant until favourable conditions help multiplication and the production of toxic effect (Joseph Koch).

Prophylaxis.—This may be considered under three heads:—

1. Treatment of the wound.
2. Control of disease in dogs.
3. Pasteur prophylactic treatment.

1. *Treatment of the Wound.*—As soon as possible after the bite, the wound should be well washed, dried and then thoroughly cauterised by carbolic acid. If this is not available, crystals or saturated solution of permanganate of potash, pure nitric acid, or nitrate of silver may be used. But these are not so efficient as carbolic acid.

To thoroughly cauterise a wound, each separate tooth mark should be dealt with in turn and care taken that the caustic actually comes in contact with the sides and penetrates to the bottom of the wound. Sometimes it is necessary to open the wound to allow the caustic free access to every part in which the virus may be lodged. Where there are definite teeth marks a probe should always be used, but care should be taken that the skin is not too extensively destroyed.

2. *Control of Disease in Dogs.*—Since by far the largest number of cases of rabies are caused by dogs, it follows that attention should be paid to the elimination of rabies amongst the dog population. This is attained by the muzzling and quarantine of dogs, and is by far the best method of preventing and exterminating the disease. In England the disease entirely disappeared with the introduction of compulsory muzzling and quarantine for six months of all

imported dogs. Besides these the following additional measures may be adopted to control the disease in dogs: (*a*) destruction of all ownerless dogs by suitable arrangements, e.g. in lethal chambers; (*b*) owners held legally responsible for damage inflicted by their dogs; (*c*) compulsory notification of all cases of suspected rabies; and (*d*) registration and licensing of all dogs by all municipalities and district boards, and any one possessing a dog not licensed heavily fined. It is therefore apparent that for successful control of rabies an earnest co-operation between the State and the public is necessary.

3. *Pasteur Prophylactic Treatment.*—The wound having been efficiently cauterised, the question of giving the person bitten the Pasteur treatment should be decided.

The physician should be guided by the following:—

(*a*) *Dog is Dead and was Rabid.*—Under these circumstances all persons bitten or licked on definite cuts or abrasions should be treated. Contact of saliva on healing wounds is devoid of any danger.

(*b*) *Dog is Suspected of Rabies.*—It is popularly believed that the brain of the suspected dog should be sent to a laboratory and if the result be positive, the patient should then proceed for treatment. Little reliance is placed even if the microscopical test be negative. Therefore when the dog is dead, and the symptoms are at all suspicious of rabies, it is necessary to go through the treatment.

(*c*) *Dog is Unknown.*—Sometimes a dog suddenly rushes forward and bites a person, and nothing more is seen or heard of the dog. In case of unprovoked attack one should assume that the dog was rabid, and the patient should be treated.

(*d*) *Dog is Alive.*—Under no circumstances should the dog be killed, for by so doing one of the most important signs of rabies, *viz.* the short duration of life (two to three days), is lost.

If the animal shows no symptoms and remains alive and well for ten days, the saliva cannot have been infective and the person bitten requires no treatment. If, however, the dog while under observation during these ten days appears ill or dies, it may be surmised that it was rabid.

The object of the Pasteur treatment is to secure active immunity against the disease by injecting gradually increasing doses of the rabies poison into the patient during the long interval that usually intervenes between the bite of a rabid animal and the development of the symptoms of hydrophobia. Unless perfect immunity can be secured during the incubation period the treatment will fail. It is useless when once the symptoms have developed. No time therefore should be lost in putting the patient under proper treatment. The different provinces have now adopted the policy of decentralisation of anti-rabic treatment, and instead of sending the

patient to the different Pasteur Institutes, the vaccine is now available for treatment at all Sadar, Municipal and District Board dispensaries and in the principal hospitals in the cities. Of late etherised vaccine has been recommended in preference to dead carbolised vaccines but it has no special advantage. The modified procedure recommended by Semple at Kasauli is to make an 8 per cent. dilution of the medulla of rabbits which have died after inoculation with rabies, in normal salt solution to which 1 per cent. carbolic has been added. This is kept for twenty-four hours at 37°C.; then diluted with equal volume of sterile normal salt solution and stored in a cool place away from light. Thus the vaccine is a 4 per cent. dilution with 0.5 per cent. carbolic. Semple's original treatment consisted of daily injections for 14 days. These were not followed by any fever and the patient was not inconvenienced in any way, and need not be confined to the house. The dosage now employed is adjusted to the estimated severity of the bite, courses of treatment varying from 7 to 21 days being given, and the strength of the vaccine varying from 2 p.c. to 5 p.c. passage brain. Sheep's brain is now used for bulk production of the vaccine.

Diagnosis of Rabies in Dogs.—This may be done in three ways :—

1. From the symptoms.
2. From the presence of Negri bodies.
3. By animal inoculation.

1. The course of the disease may be divided into three stages; premonitory stage: stage of excitement; and paralytic stage. The first two stages may be transient or absent, when it is generally known as "dumb or paralytic rabies." The first symptom noticeable is a change in the disposition of the animal and a change in the character of the bark. The animal prefers dark corners. Before the dog shows any outward manifestation, it will bite a stick held before it. It is easily excited and becomes restless and subsequently may become furious and even show signs of delirium. It rushes about attacking every object, and dogs suffering from furious rabies often run long distances (20 miles or more) biting and inoculating men and animals on the way. Paralysis, however, soon sets in, first starting on the hind legs and then becoming general. The course of the disease is always rapid, from four to five days, rarely exceeding ten days.

2. The presence of *Negri bodies* in the brain of rabid dogs is constant and is considered as practically conclusive evidence of the existence of rabies. These bodies should always be searched for. In the search for Negri bodies the following rules should be observed :—

(*a*) Do not kill the animal immediately after it bites the

victim, but keep it under observation for ten days. If it remains healthy, this is absolute proof that the animal was not suffering from rabies. If, however, the animal shows signs of illness, either allow it to die naturally or kill after three or four days.

(*b*) Do not shoot the animal in the head. Remember if the brain is destroyed, or blown out, or badly damaged it may render satisfactory examination impossible.

(*c*) Send the whole head to the laboratory well packed in ice.

3. The diagnosis by inoculation test has been given up in favour of the foregoing methods, as this requires so much time (owing to the long period of incubation) that it is of no practical value in deciding whether or not the Pasteur treatment should be adopted.

Anthrax

Anthrax is an infectious disease of animals, but transmissible to man, caused by *Bacillus anthracis*, which occurs in the blood of infected individuals, and in the soil and various other materials after these have been contaminated.

The most dangerous are dusty wools and those containing fallen fleeces. The following wools are dangerous: (1) East India or goat's hair, (2) Persian wool, (3) East India wool, (4) Turkey mohair, (5) Russian camel hair, (6) Cape mohair, (7) Alpaca.

The bacillus when exposed to air rapidly forms spores. These spores are encapsulated and are resistant to heat and disinfectants, and are far more difficult to destroy. Countless numbers of these spores are enclosed in the dried-up clots and serous discharges which saturate hides, hair, etc., of animals which have died from this disease.

The infection assumes various forms. Thus cutaneous anthrax, or *malignant pustule* is formed by inoculation or contamination of open wounds, the most common sites being the face, neck or upper extremities. Pulmonary anthrax, or *woolsorters' disease* with symptoms of septicæmic infection; and *intestinal anthrax* caused by the infection being carried into the intestine giving rise to fever, vomiting, pain, dyspnœa and cyanosis; this is rather rare. The last two varieties are generally known as internal anthrax.

Anthrax in Lower Animals.—Most of the domestic animals are liable to the disease and are infected in the same way as man. Sheep and goats are most susceptible to infection by inoculation or ingestion. Cattle are easily infected through the alimentary canal. Cold-blooded animals, birds, dogs and cats offer considerable resistance.

The discharges of the infected animals may contaminate the grass, and the spores under suitable conditions live for a

long period. Healthy animals feeding on infected pasturage may become infected through abrasions or wounds in the mouth. The infection is usually carried through food contaminated by the bowel and other discharges of diseased animals.

The *incubation period* is usually 2 to 5 days.

Etiology.—Man is usually infected from wool, hair, hides and skins. The spores may also be carried into the mouth in breathing or swallowing, and into the skin through some cut or open wound. Therefore tanners and others who work in hides and skins are liable to infection. Infection is also common during killing or skinning diseased animals. Cases are also on record where the infection occurred by using infected shaving brushes. It has been suggested that the poison may be carried by flies and other insects.

Washing does not exclude the danger of anthrax by removing the blood and dirt, and it has been shown that free bacilli in the water subsequently contaminated the wool. In the worsted industry more cases occur *after washing* than before, and in the woollen industry *after carding* than before this operation. When looking for anthrax bacillus in hairs, etc., which are supposed to have given rise to infection, such samples should be selected which give the chemical reaction for blood. Moreover it has been found that blood-stained material, even when well washed, and the dust arising therefrom, are the usual means of spreading the spores.

Prevention.—Proper prevention of anthrax implies control of the disease in animals. All animals suspected of suffering from the disease should be isolated and whenever possible killed. The carcase should be burned or buried unopened with lime, at least six feet under the ground. As the bacilli do not produce any *spores* in the absence of *oxygen and are mainly found in the blood and internal organs, it is important that dead animals should not be opened or any blood shed.*

As several cases of anthrax have been reported from the use of shaving brushes, these should be looked upon with suspicion unless they bear the imprint of the manufacturer. They are sterilised by soaking at a temperature of 110° F. for four hours in a 10 p.c. solution of formalin and the brush so agitated as to bring the solution in contact with all the hairs; or by washing in warm water with soap and washing soda, followed by immersion for half an hour in warm weak soda solution. Anthrax spores imbedded in the handles of shaving brushes are usually inaccessible to disinfection.

The Anthrax Prevention Act of 1919 regulates the importation into the United Kingdom of certain goods likely to be infected with anthrax. It is declared: That all goat hair produced in or exported from or through India, and all wool and animal hair produced in or exported from or through

Egypt, including the Anglo-Egyptian Soudan, and all goods mixed therewith, are goods likely to be infected with anthrax, and that such goat hair and wool and animal hair and all goods mixed therewith are considered as infected goods and are required to be disinfected at the port of Liverpool.

The 'Duckering' disinfection process is considered to be the most reliable method of treating imported wool and hair. This implies (*a*) warehousing the material, (*b*) disinfection, (*c*) re-baling, and (*d*) recovery of the grease from the soapy effluent.

The operations of disinfection, etc., are carried out as follows:—

1st stage, Preliminary treatment.—This consists of agitation by means of rakes for half an hour in soap water solution containing some alkali at a temperature of 102° F. By this means the spores are rendered susceptible to the action of disinfectants and cleanses the wools.

2nd stage, Disinfection.—The material is agitated as before for twenty minutes in a $2\frac{1}{2}$ p.c. formalin solution. By this process the bulk of the spores is destroyed.

3rd stage.—This consists in drying in a current of hot air at a temperature not higher than 160° F. As the moisture is driven off most of the surviving spores are destroyed.

4th stage.—The wool is conveyed to the cooling machine where it is cooled in a current of cool air. The wool stands for some days to ensure further destruction of a few surviving spores by the formalin solution.

Other preventive measures are:—

1. Educating the workmen regarding the nature and fatality of the disease.
2. All foreign hairs and hides from infected or suspected places should be scheduled under the special rules.
3. Dry hides and skins should be covered in canvas bales, and handling reduced to a minimum by making arrangements for their mechanical removal.
4. The hands of workmen should be free from abrasions and protected by gloves which should be disinfected after use.
5. The substitution of *wet* for *dry* hides.
6. Hides should not be carried on the shoulders.

Diseases due to Contact Infection

Leprosy

A disease caused by the growth of *Bacillus lepræ* (Mycobacterium lepræ), commonly called the leprosy bacillus in the body, and the reaction of the tissues to its presence.

History.—The disease is of great antiquity, and there is some evidence that it is of comparatively recent introduction into Europe; possibly it was imported from Egypt. The 1st

allusion of the disease in England refers to about the year 950. Very soon after leprosy began to decline in Europe it spread to the West Indies, and the northern parts of South America and Mexico, being carried by infected Portugese and Spanish invaders, and later by Negro slaves and Chinese and Indian immigrants. It is interesting to note that the aboriginal American Indians are free from leprosy.

Nearly all the countries with the highest incidence of leprosy are situated in humid, hot tropical areas of Africa, Asia and America.

The evidence of the existence of leprosy in India in remote periods is of a more definite character. Reference is made to leprosy in the 14th and 16th centuries B.C. and facts are accumulating to show that the disease found its way to Greece through Asia Minor.

Leprosy now is more or less a disease of the tropical and subtropical countries, and with the exception of a few insignificant islands it appears to be an important factor in the pathology of nearly all warm climates.

Heider estimated the lepers of the world at about two millions. The census of 1921 estimated 102,513 lepers in India, but these figures were collected by enumerators unskilled in the diagnosis of the disease. Recent surveys carried out by expert workers indicate that the actual number in India is from a half to one million.

The disease has been recently introduced into certain virgin soils. For instance in the Sandwich Islands it was unknown before 1848, and in New Caledonia until 1865.

B. lepræ was first described by the Norwegian leprologist, Hansen (1874). Previous to this the general view held was that leprosy was a hereditary disease, though Hutchinson held that it was caused by the eating of decomposing fish.

Etiology.—Leprous lesions are the result of the response of cells, and specially of the endothelial cells of the capillaries, to *B. lepræ*. The degree of this celullar response varies in individuals and in each individual it varies from time to time. The greater the resistance of the patient to the disease, the greater is cellular response. While weak cellular reaction to *B. lepræ* in the tissues leads to ingestion of the bacilli by the cells, in the cytoplasm of which they tend to multiply, a strong cellular reaction is accompanied by phagocytosis and destruction of the bacilli. Thus any debilitating cause in an already infected subject may lead to the multiplication and spread of the bacilli; while the removal of debility may be followed by strong cellular reaction and destruction of bacilli.

Seeing that leprous lesions are caused not by toxins given off by bacilli but by cellular reaction to the bacilli, lesions may be clinically inconspicuous and unrecognisable during a period of depressed resistance due to some other

accompanying diseases, although during this period the infection is increasing and spreading rapidly. In proportion as debility is recovered from, cellular response takes place and clinically visible lesions are formed and develop. Leprous lesions therefore often more or less disappear during accompanying illness and appear conspicuously during convalescence.

During the first few years of life, also, resistance to leprosy is depressed, and young children born of leprous parents, or who otherwise come in contact with infection, are particularly susceptible. In such children the infection may be broadcast throughout the body, but definite lesions may only begin to appear when the susceptible age is past. These become as a rule the advanced infectious cases of the next generation; whereas patients who have been infected in adult life generally remain non-infectious cases, unless for any reason their general health becomes seriously impaired, and the infection has thus an opportunity of spreading. The control of leprosy is therefore very largely a matter of preventing the infection of young children. If this were uniformly possible leprosy would probably disappear within a few generations.

In leprosy, as in tuberculosis, small infections with bacilli tend to increase the resistance, while large infections depress it. It is therefore exceedingly important that isolation from infection and the beginning of treatment should take place as early as possible before the threshold of lowered resistance has been passed.

Though leprosy may involve the internal organs, it is principally a disease of the skin and the peripheral nerves. It takes a greater degree of resistance to evoke a cellular response in the nerves than in the skin. In moderately resistant cases therefore the infection is unable to flourish in the skin, the bacilli being destroyed by the cellular response which their presence evokes. In the less resistant nerves however bacilli are able to survive; as a rule they appear to enter the sensory nerves at their skin terminals and spread up till they reach the nerve trunks. Hence the formation of *nerve* leprosy in moderately resistant patients.

Prophylaxis and Leprosy Control.—While tuberculosis is principally a disease of congested towns and industrial areas, leprosy is in India a disease of the villages. It is most common in famine areas and in regions where semi-aboriginals form a large proportion of the population. These people have abandoned their tribal health laws which formerly kept them free from infection. They leave their poor soil, especially in famine years, in search of work in crowded towns, and there contract the disease from fellow labourers from highly endemic areas. Later they return to their villages and spread the disease there. The reverse takes

place when labourers from highly endemic areas go to work in hitherto leprosy-free areas and infect the local inhabitants. This process of infection has been increased and speeded up of recent years due to the improvement of communications and the facilities for road and rail traffic.

In attempting to control leprosy it is important to make a clear distinction between infectious and non-infectious cases. The latter are those in which acid-fast bacilli cannot be found on routine examination of the skin and nasal mucosa, the infection being chiefly confined to the nerves and therefore not likely to spread to contacts. Recent surveys of villages in highly endemic areas of Bengal show on an average 80 per cent. of non-infectious, 10 per cent. of slightly infectious and 10 per cent. of highly infectious cases.

There are probably at least one million people with leprosy in India, probably some 200,000 of which are infectious cases. In the leprosy asylums, homes, hospitals and colonies at present in India there is accommodation for only between 5 and 6 thousand cases. Obviously therefore leprosy cannot be controlled by institutional isolation. Even if sufficient accommodation and money were available, nothing short of compulsion would lead the majority of patients to enter institutions; and compulsion widely applied has always been found to defeat its own end by leading to concealment of the disease.

Institutions are necessary for certain cases, especially those who are suffering from "lepra reaction" and from other accompanying diseases, and for those who require surgical treatment. But the disease can much more suitably be controlled by locally supported clinics and by locally organised propaganda with a view to the treatment of all cases and the isolation of all infectious cases inside the village areas. In Bengal the Union Board area has been found the most suitable unit for organisation of such leprosy control centres.

The control of leprosy in the towns must depend to a large extent on its control in the villages. Even were it possible to remove to effective isolation colonies the thousands of beggar lepers in our large cities, the problem would *scarcely be touched thereby. Unless preventive police* measures are adopted their place would soon be taken by other leper beggars or those at present potential beggars from the surrounding districts and provinces. Besides this the spread of leprosy is to only a slight extent dependent on beggars; the real source of infection is in the homes where the disease is spread by infectious relatives, servants and neighbours, chiefly due to the ignorance of the public regarding the disease.

In India the control of leprosy along lines similar to those sketched above should be an integral part of the Public

Health organisation in every endemic area. Leprosy, once it has passed the threshold of lowered resistance, is one of the most difficult diseases to cure; but with properly organised public health units it should be one of the easiest diseases to prevent and control.

VENEREAL DISEASES

Under this are included syphilis, gonorrhœa and chancroid or soft-sore. Of these, the first two diseases are of very great public health importance. They are widely prevalent throughout the world and lead to several grave consequences. It is estimated that in most countries about 8 to 10 per cent. of the population are infected and in India about 600,000 cases are treated every year in the Government institutions alone. The latter figure is but a fraction of the total number of the cases occurring in the country. As regards the public health importance of these diseases it is needless to point out that they cause not only physical, mental, moral and social degradation of the individual attacked with them, but also lead to the disruption of the peace and happiness of the family and the deterioration of the health, vitality and physical progress of the community. It is well-known that venereal diseases are responsible for 35 per cent. of all insanity, 40 per cent. of mentally defectives, 40 to 60 per cent. of blindness, 50 per cent. of sterility, 30 to 40 per cent. of abortions and miscarriages, and a high percentage of diseases of the heart, blood vessels, and the nervous system. Despite these serious consequences it is unfortunate that in all countries of the world the public and the public health officials do not give these diseases the same amount of attention as they give to other communicable diseases. Knowing that venereal diseases are preventable, it should be the clear duty of the public health officials not to discriminate between these and other communicable diseases. No useful purpose will be served by refusing to accept facts and face disagreeable truths. Every public health scheme before it can be called complete or satisfactory, must include a campaign against venereal diseases and although the measures of control may be difficult to enforce and beset with many practical difficulties, and consequently the progress very slow, yet there is no doubt that if judiciously and persistently applied, good and lasting results will ultimately be achieved.

Syphilis.—It is an infectious disease running a prolonged course, with lesions and symptoms of extraordinary diversity and capable of being divided into four distinct stages—primary, secondary, tertiary and quaternary. The primary stage generally starts within 2 or 4 weeks of infection and is characterised by the development of a chancre and the enlargement of lymphatic glands. The secondary stage comes on 6 to 12 weeks after the primary

stage and is characterised by cutaneous lesions (macular, papular or squamous and rarely vesicular or pustular), enlargement of the lymphatic glands and affections of eyes, joints and bones. The tertiary stage comes on 2 to 3 years after the secondary stage and is characterised by ulcerating and necrotic lesions of the skin and gummata of the internal organs. The quaternary or parasyphilitic manifestations come on after 10 to 20 years and are characterised by disorders of the nervous system. such as general paralysis of the insane and tabes dorsalis.

The *incubation period* is generally 2 to 4 weeks—may be 3 months—the average being 25 days.

History.—The first authentic record of syphilis dates from 1495. A severe epidemic of the disease occurred in Europe and was attributed to Columbus' crew bringing it from America. It was then known as "Morbus gallicus" or French pox. Since then there are a number of important landmarks which deserve special mention. In 1496 it was recognised that the transmission of syphilis was by sexual intercourse. In 1903, Metchnikoff and Roux demonstrated that apes could be infected and that the infection can be prevented by the use of calomel ointment. In 1905, Schaudinn discovered the ætiological agent *Treponema pallidum*. In 1906 Wassermann elaborated a serological test now known as the Wassermann reaction for the diagnosis of the disease. In 1910, Ehrlich discovered Salvarsan for the cure of the disease. In 1911, Noguchi cultivated the organism in a pure state and described methods for the differentiation of the organism from other spirochætes.

The *ætiological agent*, Treponema pallidum, is a thin delicate actively motile spirochæte with tapering ends, 4 to 14μ long and 0.25μ thick. It has 10 to 12 regular, closely-set spirals each of which is about 1μ long. The organism is very frail and is killed readily by moist heat (in 1 hour at 51°C.), by drying and by weak antiseptics. It is known to remain alive for half to one hour in a drinking glass, 11 to 12 hours in moist towels, and for a few days in the tissues and body fluids kept under laboratory conditions.

Source of infection.—This is generally an infected person. The nature of the infective material varies with the stage of the disease. In the primary stage the chancre and the lymphatic glands are full of spirochætes and at times also the blood; the infectivity is high at this stage. In the secondary stage all lesions, the blood, the lymphatic glands, saliva and the semen contain spirochætes; cases in this stage are highly infective. In the tertiary stage the gummata contain relatively few spirochætes and the infectivity of the case is relatively less. In the quaternary stage the spirochætes are mostly in the brain cortex and the infectivity is least. While a syphilitic with lesions is infective, a person

with no lesions may also transmit the disease. Often the semen contains the spirochætes after apparent cure. The infectivity is highest in the first two years of the disease and then it gradually gets less and less year after year.

Mode of spread.—This may be either direct or indirect. Direct infection may be acquired through adulterous relations of venereal origin, through marriage (one or other party being infected), or congenitally by fœtus *in utero*, through a wet nurse, or accidentally through abrasions. Indirect infection may arise from the use of infected clothing, towels, razors, surgical, dental and tattooing instruments, pipes, drinking glasses or through the hands of physicians, nurses and midwives.

Gonorrhœa.—It is an acute infectious disease characterised by inflammation of the urethra, painful micturition purulent discharge and a liability to certain complications, such as ophthalmia, endocarditis and arthritis.

The *incubation period* is 1 to 3 days.

Ætiological agent.—The causal organism which was discovered by Neisser in 1879, is a gram-negative diplococcus known as *Neisseria gonorrhœæ*. In 1885 Bumm cultivated the organism in serum media and the rough experimental inoculation of the organisms into human urethra demonstrated its ætiological role. The organism is not infective to other animals. The resistance of the organism is low; being killed at 55°C. in a few minutes or when dried or exposed to air. Cultures of the organism in the laboratory lose their virulence very soon.

Source of infection.—This is generally a case of gonorrhœa. In man the urethral discharge, and in woman the urethral, vaginal and cervical discharges, are infective. The infectivity may persist for a large number of years.

The **mode of spread** is chiefly direct through sexual intercourse. In a small number of cases it may be indirect through the use of infected towels, bath tubs, and water closets.

Control of Venereal Diseases.—An eminent authority on venereal disease control writes: "To diminish the amount of venereal infection requires education, publicity, notification, laboratory facilities for diagnosis, dispensary and hospital facilities, public health nurses, social service, and good laws actively administered. Medical institutions should give more time to the diagnosis and handling of early cases, since at this time the best results in treatment and prevention can be offered. A stricter supervision of barber shops, restaurants, hotels, soda water fountains, infant asylums and schools should be maintained. Prostitution should be made difficult and distant and early treatment of all cases instituted. Medical prophylaxis should be better understood and the importance of personal hygiene impressed; and insistence

should be stressed upon continence and efforts made to improve the moral and physical fibre of mankind."

So far as India is concerned, very little has been done on any of these directions for the control of venereal diseases. Even in the larger cities the facilities provided are extremely meagre. A glimpse at the European methods may help to illuminate the future course of venereal disease control to be adopted in India. In England most patients are treated in public clinics under the supervision of the Venereal Disease Division of the British Ministry of Health. Very few private practitioners treat their own cases. The public clinics are attached to hospitals, and are profoundly influenced and directed by the Central Government. In Germany venereal disease control is rendered through sick-benefit organisations. It is quite effective because three-fifths of all Germans belong to the insurance associations and are entitled to free treatment and because eighty per cent. of all physicians work for insurance companies. France has recently adopted Governmental control and there are now many free venereal disease clinics and private practitioners are also permitted to treat cases at public expense. In Belgium private practitioners who treat venereal cases are subsidised by the Government and get a free supply of drugs and equipment. The free venereal disease clinics in Vienna have for many years been among the largest and most notable in the world. The success of any scheme to combat venereal disease in India will largely depend upon the energy and enthusiasm of the medical profession and the public health authorities, and upon the co-operation and support of the Government and the public. All these should strive to root out the diseases by adopting a scheme on the following lines.

1. That the services of fully qualified and experienced medical experts be utilised to supervise venereal clinics and to give clinical lectures to graduate and post-graduate students.

2. That medical students, men and women, be made to attend a course in venereology as a part of the normal medical curriculum and that a post-graduate course be opened if necessary free of cost, for medical practitioners.

3. That care be taken to include in the scheme specialist women medical officers, for treatment of purdah women, working women and children, many of whom are often innocently infected, or have inherited venereal disease.

4. That all treatment be provided free of cost, and without unnecessary publicity, and that, as far as possible, clinics be established in all the existing hospitals, as an integral part of the normal care of the sick population.

5. That in the administrative arrangements for free clinics, care be taken to open the clinics at such hours (day or night) as will make it possible for all sections of the community to attend without loss of employment.

6. That special separate facilities be provided for the treatment of infected expectant mothers, prostitutes, soldiers and sailors.

7. That an endeavour be made, through trained health visitors and health officers, to encourage the attendance of cases and contacts for examination at free venereal clinics (without any compulsory legal measures, such as notification of disease, or compulsory detention until cure) and that all consideration and friendly courtesy be extended to venereally diseased persons remembering that on the goodwill of the patients towards the medical authority depends the continuation of treatment and the successful control of the spread of infection.

8. That popular lectures regarding the dangers of venereal diseases and the methods of disinfection and use of prophylactic methods be given in venereal hospitals, army and navy camps and other institutions for adult men and women and that chemists be permitted to sell outfits containing instructions to grown-ups at all hours of the night.

9. That legislation be passed prohibiting practice by quack doctors, advertisement of quack medicines and publication of obscene books and literature and that early steps be taken for abolishing houses of prostitution and persuading the inmates to give up their disgraceful profession and take to useful occupations in which they can earn a decent living. When these are not practicable, arrangements should be made for frequent medical inspection and certification of prostitutes.

10. That midwives and *dais* be trained in the routine methods for prevention of ophthalmia neonatorum, and that free issues of necessary drugs and equipment be made through approved medical authorities.

11. That in all publicity campaigns, stress be laid on the normality and healthiness of chastity.

12. That in view of the fact that one of the best methods of prevention of venereal diseases is a continent life, all efforts be made by the different communities to promote the moral training of young people and popular lectures be given on such subjects as self control, self respect, responsibility to self and society, and continence.

The value of *medicinal prophylaxis* in venereal disease control is questioned by some authorities. The preventive outlook on venereal diseases from the point of view of the public health official however has given the subject an increasing importance. Although at first sight the large number of social, ethical and moral questions centering round the subject of medicinal prophylaxis may make some officials reluctant to recommend its wide employment, yet when they seriously consider the question from a scientific or public health point of view they cannot but set aside these objections.

Medicinal prophylaxis is not necessarily antagonistic to the other methods of prevention such as suppression of prostitution, sound moral education and so on. The effectiveness of medicinal prophylaxis has been amply demonstrated in recent years and in those countries where it has been widely employed, the claim has been made that it has reduced the incidence of venereal diseases to less than a third. These results make it quite impossible to ignore it as a factor in the control of venereal diseases and a brief description of the method employed will not therefore be out of place here.

For Syphilis.—Use of condom; washing of genitalia with lotions of potassium permanganate or mercuric perchloride (1 in 1000); innuction of calomel ointment (30 per cent.); Sulfarsenol in suitable small doses if necessary.

For Gonorrhœa.—Use of condom; urethral injection of potassium permanganate (1 in 1000) or protargol (10 grs. to an ounce) or argyrol (one dram to an ounce) in quantities of 5 to 10 c.c. immediately after intercourse. Irrigation with weak potassium permanganate (1 in 5000) morning and evening for 3 days and alkalies by mouth to render the urine alkaline.

CHAPTER XXI

MEDICAL INSPECTION OF SCHOOLS

THE progress of civilisation, the welfare of the individual, the general good of society are contingent upon the efficiency of the education imparted to the children in school; and when it is remembered that from three to five hours daily of six days in the week for from seven to eight months in the year are obligatory for children and young lads, the importance of a careful sanitary oversight of schools becomes at once apparent. Unfortunately school hygiene is very much neglected in this country, although within recent years some attempt in this direction has been made by the Public Health Departments and the different Universities. Modern civilisation demands education on a wide scale, but this will yield no fruitful result unless the waste of health of the future parents from bad air, bad food, bad light, overcrowding and mingling of the sick with the healthy, is prevented.

Owing to the fact that a large proportion of recruits during the South African War had to be rejected for ailments of many kinds, the necessity of increased superintendence of physical growth became manifest, and a Royal Commission of Physical Training was appointed in 1903. The findings of the Commission were: (1) that many of the defects found in the recruiting stations had their origin in early life; (2) that physical training in schools could not be efficiently developed except under medical supervision; and (3) that even for the purpose of general education medical inspection of the school children was called for.

The objects aimed at in the medical inspection of schools are:—

(1) The detection of contagious diseases, thereby protecting the child and the community.

(2) The detection of physical defects which prevent the child from acquiring a full education, with the least sacrifice to his physical welfare.

(3) To find the capacity of the individual pupil to acquire knowledge in accordance with his mental and physical status.

(4) To ensure the best possible hygienic surroundings for the child while he is at school.

(5) To bring about a close relationship between the school and the home, so as to carry out more successfully the other ends of medical inspection, and ensure treatment of discovered defects.

(6) To teach the practice of hygiene and healthful living both in school and at home.

To accomplish these objects trained physicians are required. In places where it is not possible to command the services of the physician, the teacher, who must have some training, may act in the capacity of an examiner and refer suspicious cases to a physician. The medical inspector should be constantly alive to his responsibilities and should be always ready to remedy defects. For in childhood many conditions may be remedied or prevented that in adult life may seriously compromise the health and usefulness of the individual.

One medical inspector to every five thousand pupils is a fair average of the number of men required for the work in any city. The number, however, will depend upon the amount of work to be done, the number of pupils in a school, the nature of the population, the probable defects found, and the system of inspection employed.

An examination of the health of about 28,256 students by the Calcutta University Health Section showed that, roughly speaking, only 38 p.c. were free from defects. Of the others about 33 p.c. were suffering from malnutrition; 34 p.c. from enlarged tonsils and adenoids; 31 p.c. from defective vision; 19 p.c. from caries of the teeth; 23 p.c. from tuberculosis, and others from enlarged liver, spleen, pyorrhœa, diseases of the heart, etc. It is a matter of deep concern that such a large percentage of students should suffer from various diseases specially from malnutrition and caries of the teeth.

The school is generally regarded as the veritable source for the spread of infection amongst children, specially measles, whooping cough, mumps, diphtheria, chicken-pox, etc. It is also important to note that apart from the children who actually contract the disease, the infections are carried home which form further sources of mischief.

Qualifications of Inspectors.—Any competent, conscientious physician may be trained for the position of a medical inspector. It is desirable to have a physician who has had previous training in the diagnosis of infectious and skin diseases and practical knowledge in examining the eye, ear, throat and nose.

The Scope and Nature of Medical Inspection.—An important part of medical inspection consists in the inspection of sanitation of school buildings and grounds. One cannot teach hygiene and healthful living while surrounded by insanitary buildings wherein classes are conducted. Attractive, well-situated, and well-kept school-rooms are in themselves an object lesson and an incentive for the pupils to live properly.

Twice a year—once in summer and once in winter—an inspection should be made, which should include every part of the building, including its drainage, water-supply,

ventilation, cleanliness, etc. All insanitary conditions should be noted and a re-examination made after some time to see if these have been remedied.

The medical inspector should begin his work by a thorough inspection of the grounds surrounding the school. The outhouses, water-closets and urinals, ventilation, cleanliness, condition of plumbing and drainage, and the number of seats in relation to the school attendance, should be carefully noted. The kind and condition of school grounds, the presence of stagnant water and overgrowth of vegetation should also be noted.

The building should be inspected for cleanliness, dampness of walls, presence of water, or accumulation of refuse. The inspection of class-rooms includes the measurement of each room and the amount of window space and lighting, and the kind of tables and benches used.

The source and purity of the water should be investigated in places where there is no filtered water-supply. The way the water is stored is equally important, and where domestic filters are used these should be examined for cleanliness, and to see if they are in working order.

A systematic examination of all pupils on admission should be made and the results recorded in a schedule. Those who require special supervision during their school course, those to be exempted from gymnastics, and those requiring special position on account of defective sight and hearing should be noted. The schedule containing these details should accompany the child all through his school course. With regard to the "general constitution," the school inspector must state for each child whether his constitution is good, medium or bad. Every fortnight, and oftener if necessary, the school doctor should visit the school and examine systematically any case brought to him and record his observations and instructions.

Duties of Medical Inspector.—

1. He shall advise as to new sites and plans of new school, exercise a general supervision over ventilation, lighting and cleanliness of the school, and periodically inspect all school lavatories and other sanitary installations.

2. On receiving intimation of an outbreak of infectious disease among the pupils attending any school, he shall at once enquire into the outbreak and take such action as may be immediately necessary, and as soon as possible report the result of this enquiry to the Board.

3. He shall advise on the necessity of periodic disinfection and cleanliness of the school with a view to the prevention of disease.

4. He shall make such examination as the Board may require regarding the mental and physical condition of the children selected for special classes, and grant any necessary certificates.

5. To the extent and in the form prescribed from time to time he shall examine the pupils attending the school, and shall preserve and maintain on an approved schedule a record of the examination of each child.

6. He shall from time to time inspect the physical exercise given in the schools.

7. If any child is reported to be suffering from any ailment, or defect, or injury, he shall as soon as possible examine the child and give such direction as may be necessary.

8. He shall, by lectures, demonstrations or otherwise, instruct the teachers in the methods of recognising the common ailments and defects of school children; in the practice of first aid for school accidents; in the general hygiene of the school and class room; and in the physiological principles underlying physical training.

9. He shall keep such records and books as the authorities may prescribe or approve, and he shall submit an annual report on the work done, and make such special report as the executive head may require.

10. He shall make periodical visits to all the attached hostels and report on their sanitary condition, surroundings, cleanliness, and condition of dietary.

11. He shall insist on the schools and hostels being whitewashed and cleaned every six months or year.

Method of Inspecting Pupils.—The medical inspector should have a routine method of conducting physical examinations. As the child enters the room, the inspector notes his gait and in a low tone asks his name and age, and by the promptness or otherwise of the answer forms a rough idea of the condition of the hearing and sometimes of the mentality. He observes any abnormalities of structure, differences between the two sides of the body, facial expression, etc. He notes the colour of the skin, presence of jaundice, anaemia or any form of rash. The mouth and throat are next examined: the presence of an odour indicates uncleanliness of the mouth, carious teeth or naso-pharyngeal catarrh; mouth breathing or signs of nasal obstruction are also noted. Eyes are inspected for any inflammation, presence of strabismus or ptosis. After obtaining all the possible data, the hearing and vision should be examined in detail. The examination of the eyes should have special attention, as no other organ of the body bears a greater influence on the child's welfare. Children suffering from word blindness, word-deafness, and moral imbecility demand special provision for education.

The following points should be noted in the schedule during the medical inspection of each child:—

I. General Information:

Name—age—sex—address—nationality.

Name of school—date of inspection—class.

Measurement—height—weight—nutrition—cleanliness—clothing.

II. Personal History :

Previous illness (before admission) from infectious disease.

Vaccination—re-vaccination—family history (anything special, *e.g.*, tuberculosis).

III. Special Conditions :

Teeth—nose—throat (tonsils, adenoids, etc.)—eye—vision—ear—hearing—speech—mentality.

IV. Diseases or Deformities :

Heart—lungs—spleen—liver—skin—anæmia—malaria—tuberculosis—rickets—special disease and deformities (squint, talipes, harelip, stunted growth, deformed chest, etc.).

Medical Officer's Signature :

General Observations :

Directions to parents or teacher with regard to diet, exercise, hours of study, cleanliness, etc.

Action taken upon the Detection of a Case of Infectious Disease.—A pupil suffering from a contagious disease, whether latent or mild, should be immediately excluded from the school. In cases of diphtheria, measles, mumps or whooping cough, the class should be inspected for more cases, and smears of the throat taken for diphtheria bacilli of the children seated nearest to the infected child. If the scholar is treated at home, the other children in the house must be excluded from school until the child recovers and the house is disinfected. This precaution is particularly necessary in case of small-pox, cholera, measles, whooping cough and diphtheria.

The school authorities should insist on the production of a medical certificate by the scholar during admission, and also when he joins the school after a vacation. This should clearly mention occurrence or not of any infectious disease either in the scholar or in any member of the household within three weeks.

The table on page 555 gives a summary of regulations regarding the exclusion of children suffering from infectious diseases or living in the same house.

Construction of School Buildings

The Building.—This must be in a healthy locality and convenient to get at; it should not be near to railroads, factories or mills. It should have ample open space.

The building proper should preferably be two-storied; where space admits, a school should contain, besides its class room and administrative offices, a. common room, and a gymnasium. One room should be set apart for the work of the medical inspector.

If there be a basement, it should be of sufficient height

for light and air to penetrate every part of it, and should never be used as a store-house for refuse.

Diseases.	Exclusion of children infected.	Exclusion of children living in the same house.
Cholera ..	Until discharged from hospital or certified as free from infection.	Until after 7 days from the date certified by H. O. that the house is free from infection.
Diphtheria ..	2 to 4 weeks after discharge from hospital. If treated at home same period supported by bacteriological examination.	Same as above, or 2 weeks or until bacteriological examination shows negative results.
Measles ..	4 weeks.	*Over 7 years*—exclude for 3 weeks those who attend infant school, or who have not had the disease. *Infants* 21 days from date of onset of the last case.
Mumps ..	3 weeks.	3 weeks only those who have not had the disease.
Chicken-pox ..	Until scabs fall off.	Infants for 2 weeks.
Small-pox ..	Same as in cholera.	Same as in cholera.
Tuberculosis ..	Exclude if accompanied by cough and expectoration.	Not to be excluded.
Whooping Cough	6 weeks or as long as cough remains.	2 weeks for all excepting those who had the disease.
Influenza ..	2 to 3 weeks.	10 days.
Ringworm ..	Until certified as cured	Not to be excluded.
Scabies ..	Until certified as cured	Not to be excluded.
Ophthalmia ..	Until certified as cured	Not to be excluded.
Trachoma ..	Until certified as cured	Not to be excluded.

Sanitary Conveniences.—Ample provision should be made for privies and urinals, one set for each storey. The urinal should be constructed of slate or stone, properly flushed by constant running water. Closets and urinals should be sufficient to meet the demands of the number of students in the school. These should be in the proportion of 5 of each for every 100 students. They should be located outside the main building, or may be in a detached portion connected with the main building by an overhead bridge. In any case these should not be too near the class room. Water-closets should be of such a nature as will allow of easy scrubbing and be provided with an automatic flush. Arrangements should be made for a supply of water for washing, and proper receptacles provided for the purpose,

which must be kept clean. In village schools privy arrangements must be made with all sanitary precautions and a sweeper engaged to clean the privy after each visit. The disposal of nightsoil must be attended to. Special care should be taken to protect the well or the tank from being polluted by indiscriminate use through carelessness of the students or the servants. Where funds would permit *septic tank latrines* should be installed. There must be a separate wash-room adjoining the bathroom, and children should be taught to use it for cleansing hands and face after play or a visit to the closet. If tap water is available, an ordinary porcelain basin with run-off to the sewer should be installed. In the absence of this, ordinary enamel basins with the water-supply in buckets should be provided.

Water Supply.—Special attention should be paid to the water-supply for drinking purposes. In villages where there is no public water-supply, the purity and suitability of water for drinking purposes must be carefully ascertained.

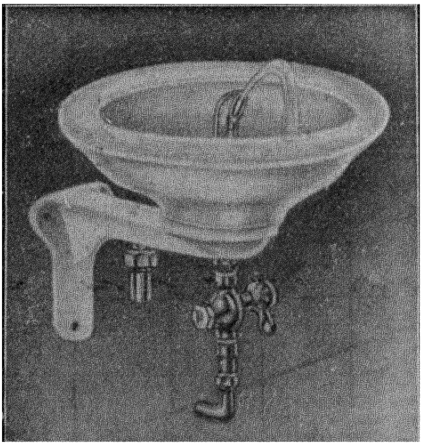

FIG. 148.—DRINKING FOUNTAIN.

The tank or the well should be inspected and a sample of water taken for chemical and bacteriological examination. If water is preserved in vessels, it must be under cleanly conditions and steps should be taken to protect the water from pollution. The use of the same cup or glass by different individuals should be prevented, unless these can be cleaned each time after use It is better to drink direct from the tap. Special "drinking fountains" (Fig. 148) may be installed whenever possible to prevent drinking from the same glass. In villages a special tank or a deep well should be reserved for drinking purposes and properly guarded to prevent contamination. A deep tube-well with a hand-pump

is quite convenient and useful. Where funds are not available the only way to avoid water-borne diseases amongst the scholars would be to have the water first clarified by the use of alum and then boiled and kept in clean vessels.

Class Rooms.—These should be large and cheerful. The minimum floor space for each pupil should be 15 sq. ft. Faulty lighting, ventilation, or sitting arrangements may directly cause many defects ; and the school inspector should see that school conditions may not be responsible for any of the defects in children. Every part of the school room should be fully lighted. The light should always come from the left or from above and the children should face a blank wall. Light from the front will be dazzling to the eyes, and light from behind is not pleasant to the teacher, it causes a shadow of each scholar to fall on his work. The windows should be so placed as to light every table evenly and sufficiently. Receptacles with carbolized sawdust or some antiseptic fluid should be placed in the class rooms and other places for spitting, etc. Students and teachers should be strictly warned against spitting indiscriminately.

Seats and Desks.—The most important articles of furniture from a sanitary point of view are the seats and desks. The seating arrangement is of great value inasmuch as faulty benches often give rise to certain orthopædic defects. In

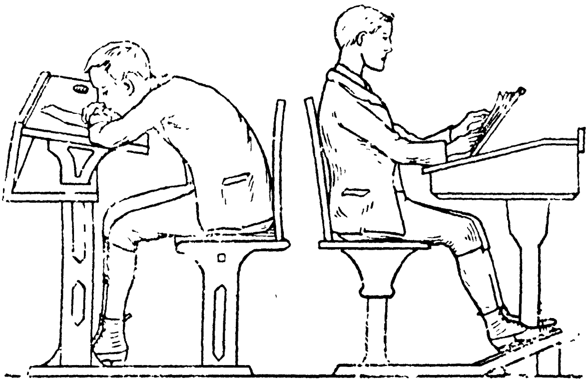

FIG. 149.—POSITION FOR WRITING IN A PLUS DESK.

FIG. 150.—CORRECT POSITION IN A MINUS DESK.

most schools the child is adjusted to the benches and the tables, with the result that in most of the seats it is impossible for the child to assume a comfortable and correct posture. Seats should be arranged parallel with one another and at right angles with the windows. Ordinarily desks should be 15 to 18 inches broad with a slope of 15° for writing and 45° for reading. The height of the child should be the only consideration for choosing desks and benches, and

therefore adjustable ones are best suited; so that every desk may be accurately adjusted to the requirements of the boys. They should not be too high nor too low, too near or too far from each other. There must be sufficient room below the desk for the knees, and the desk should be low enough for the elbow and forearm to rest comfortably without bending the back. When this is not possible the following sizes recommended by Priestley Smith should be installed:—

Height of scholar	Height of seat from floor.	Width of seat.	Height of desk and back from seat.
2½ to 4 feet	13 inches	10 inches	8 inches
4 to 4½ "	14½ "	11 "	8¼ "
4½ to 5 "	16 "	12 "	9½ "
5 to 5½ "	18 "	13 "	10½ "

The construction of the back-rest is very important, and it should support the spine in the lumbar region in all positions. Any support above the hollow of the back is unnecessary and encourages the slouching position. The distance between the seat and the desk should be such that the scholar may read or write on it without leaning forward more than a little and without entirely losing the support of the back. It follows, therefore, that unless the desks and the benches are constructed with full regard to the above points there is possibility of defect in sight, injurious effects as to posture and wrong habits of carriage.

Desks are classified into three varieties depending upon their relationship to the seats, *viz.*—

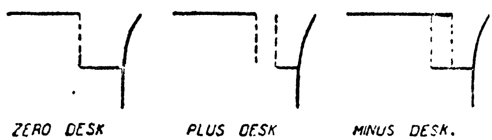

FIG. 151. - RELATION OF SEAT TO DESK.

1. The "Plus" desk. In this type there is a space between the edge of the seat and a vertical line from the desk.
2. The "Minus" desk. Here the vertical line falls on the seat.
3. The "Zero" desk. Here the vertical line from the desk touches the edge of the seat.

The desk should be of the "minus" type and the height of the seat so adjusted that the thighs of the scholar are horizontal, legs remain vertical and the feet rest flat on the floor.

Posture.—Every care should be taken to prevent the scholar from acquiring physical defects in schools. Posture in sitting therefore is important. A too much stooping posture leads to myopia, contracts the chest and interferes with respiration. It puts an extra strain on the heart, and causes curvature of the spine.

Ventilation.—Class rooms must be freely ventilated. The air may become vitiated by the respiration of the students and teachers, by the fermentation and putrefaction of animal or vegetable organic matter, by dry excreta, and dirt from shoes. Germs of communicable diseases located in the respiratory tract of the students are added to the exhaled matter. These germs and dust particles adhere to the moist mucous membrane of the respiratory tract, throat and mouth, and may later reach the lungs, if not removed by the excretions of those organs. For each scholar about 200 cubic feet of space, 15 square feet of floor space, and 1500 to 1800 cubic feet of fresh air per hour may be taken as an average requirement. Play-grounds serve the double purpose of allowing space around a school for light and air, and furnishing the necessary means for the children to obtain exercise and pleasure out of doors.

School Hostels.—There are two kinds of hostels generally known as "licensed" and "unlicensed." The licensed ones are under the control of the University, or the school or the college authorities. The unlicensed ones are without any control whatsoever. According to the last University Commission Report (1919) during the year 1916-17, as many as 1,896 students were living in unlicensed houses in Calcutta. The hostels should be periodically visited by the medical inspector, and no student should be allowed to live in any unlicensed hostel. In addition to the inspection of general sanitation with regard to water-supply, privies, water-closets, drainage and ventilation, the medical inspector should keep an eye on the food. This is of vital importance to the health of the present generation of students. Most of the students are sickly, ill-nourished and dyspeptic. The unfavourable conditions of health and physique of the students are due to underfeeding, lack of exercise, bad living conditions, and improper diet. The medical inspector should also see that every student acquires a habit of eating at regular hours, and takes enough outdoor exercise.

The building should be constructed on sanitary lines so that each room may have ample provision for cross ventilation. Each room should be big enough to accommodate two boys with a floor space of at least 60 sq. ft. per head. It

should not be crammed with furniture. One bed, one chair and a table for each scholar are all that is required. A shelf or an almirah may be supplied. The lighting is always faulty where there is no provision for gas or electricity. Hanging lamps are convenient and more desirable than table lamps as the glare of the light affects the eyes. Every hostel should possess a common room and one or more dining halls.

The kitchen should be in a detached portion separated from the main building. The garbage should not be thrown at random but collected in proper receptacles.

The drains, etc., should be properly flushed and kept clean. There must be a sufficient number of privies or water-closets and urinals.

Every hostel should have sufficient open space, and wherever possible, be provided with an open lawn where the scholars can have outdoor games and spend the evening in the open air.

Administration.—The power of medical inspection of schools and attached hostels should be vested in a Board under the control of the University or the Director of Public Health. All the medical inspectors should be under this Board. Where a large number of inspectors is required, as in Calcutta, it is necessary to have one or two supervisors under one director. The director will have to supervise the work of all inspectors and success will largely depend upon the efficiency and skill of the director. He must have executive ability combined with a thorough knowledge of the subject of medical inspection, and be a good disciplinarian capable of directing wisely.

The director should outline a practical system of inspection, which must be simple and not burdened with too much clerical work. He should see that there is uniformity in work, and visit the schools and the hostels occasionally.

The chief difficulties are administrative rather than educational or scientific, and the feelings and prejudices of the parents have to be considered. A new element has to be introduced into the school life with the least possible disturbance and inconvenience. In the case of school hygiene, two departments of public administration will have to be brought into organic connection, those of public health and of public education.

THE BENGAL MUNICIPAL ACT, 1932

SEC. 396.—Empowers the Local Government to make rules—

(d) Providing for the sanitary inspection of all schools and colleges and for the medical inspection of children immediately before or at the time of, or as soon as possible after, their admission to a primary or secondary school and on such other occasions as the Local Government may direct, and authorising the Commissioners to make such arrangements as the Local Government may approve, for attending to the health and physical condition of the children educated in such schools.

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CHAPTER XXII

MATERNITY AND CHILD-WELFARE

The importance of the question of child-welfare will be evident from the infantile mortality rate for Calcutta, *viz.*—386.0 in 1920; and 330.0 in 1921; 373 in 1926 and 340 in 1927. Out of the total mortality in India, 23.7 per cent. occurred in infants (under 1 year) in 1927 against 24.6 per cent. in 1926. The corresponding figures for England and Wales are 10.7 and 9.5 respectively.

These figures show the high rate of infantile mortality which prevails in Calcutta, not to mention the rural areas, where the condition is still worse. This heavy mortality is due to several causes, *viz.*, high birth-rate, ignorance on the part of the mother, improper feeding, exposure to insanitary surroundings, adherence to outworn prejudices connected with parturition, quack midwives, immaturity of mothers, etc. Of the total infantile mortality about 36.5 per cent. in Calcutta and 32.12 per cent. in whole India, occurs during the first week of life, and is due mostly to neglect through ignorance, premature birth, debility, and tetanus neonatorum.

The Corporation of Calcutta provides trained midwives to attend to confinements amongst the poor, and women health visitors to give necessary advice to prospective mothers with regard to the sanitation of pregnancy and the proper methods of rearing children. Although child-welfare centres have been started in large towns, the whole rural population still remains neglected.

The movement for preserving the life of the infant and the child involves other important factors, and the desirability of keeping an eye on the health of the prospective mother, and of bringing to full term and safe delivery the large number of miscarriages and stillbirths, and of providing trained midwives in confinements for the mothers, are all important factors in the preservation of the national life and vigour.

Infant mortality is a sensitive index of health conditions, especially as regards the general sanitation, under which the people live. It is these conditions which require attention, if any real influence on infant mortality and on the health of the nation is to be exercised.

The solution of the problem of maternity and child-welfare is to be found in the circumstances surrounding the life of women of the poorer classes, especially in the rural areas, who are fighting daily against destitution and want. There can be no question that poverty and want of elementary

ideas in domestic hygiene are the chief causes at work: poverty necessitating bad housing, poor and often ignorant feeding and clothing, and insanitation.

The maternity and child-welfare scheme should embrace the following, *viz*:—

(1) The protection of motherhood.
(2) The protection of infancy.
(3) The protection of childhood.

The Protection of Motherhood.—In India the importance of the protection of the mother becomes more apparent when it is realised how the health of women is being undermined by early and repeated child-bearing, prolonged nursing, insanitary and unhygienic surroundings, bad living conditions, overwork and chronic malaria. About 25,000 to 30,000 mothers in Bengal die every year from causes connected with child-bearing. *Pernicious anæmia* and *chronic diarrhœa* with slow fever (commonly known as *Sutika*) are the common diseases from which women who have had repeated pregnancies suffer often with loss of life. Owing to the extra demand on the part of the fœtus the calcium content of the blood of the mother becomes diminished during pregnancy and the period of lactation. This and the want of fresh air and sunlight, owing to the rigorous purdah system in some parts of India, are responsible for the bones of the mother to become soft and the condition known as *osteomalacia* develops (*see* page 128). These diseases should be rare with proper education, nutrition, and abolition of time-honoured prejudices. The protection of the mother, therefore, is an important item in any scheme, as upon the health of the mother depends the health and vitality of the child. This protection should be given during ante-natal and post-natal periods.

Statistics show that death-rate among women is very heavy between the ages of 15 and 40, the main child-bearing period. In 1921 alone maternal causes must have been responsible for over 60,000 deaths in Bengal. The maternity death rates for 1000 births in England and Wales were 3.86, 4.01 and 4.11 for 1925, 1926 and 1927 respectively. As compared to this the rate was 19.3 and 24.7 for Assam, 11.8 and 8.7 for all towns in the Bombay Presidency, and 11.4 and 10.8 for the Madras Presidency for the same years. It has been pointed out that every day in England and Wales 10 women die in childbirth apart from those who die years after from the late results of childbirth, which according to Blair Bell is 60,000 per annum. (F. J. Browne, *Journal of State Medicine*, 1931).

The immediate detection or immediate correction of any deviation from normal, goes a long way towards removing most of the difficulties and dangers associated with pregnancy, labour and puerperium. Similarly improved training of the medical students and midwives, the necessity for examina-

tion and supervision during pregnancy, desirability of non-interference with natural labour are important matters requiring careful consideration.

(*a*) *Ante-natal Period.*—Sufficient information is already available to show how important an element in the problem of child-welfare is the period when the child is wholly dependent for its continued existence on the health and well-being of the mother. In view of the enormous proportion of infant deaths occurring during the first week or the first month of life, we have to consider the causes to which these deaths are ascribed. This leads us directly to the period antecedent to its birth. Stillbirths and deaths from immaturity very inadequately represent the total volume of life lost during ante-natal states. Miscarriage is in many instances a perverted habit, beginning most probably in disease or injury, but repeating itself in recurring pregnancies. Other phases of ante-natal problems which require careful enquiry are the occupation of the mother, pregnancy occurring too early in life, effect on mother and child of rapidly following pregnancies, influence of syphilis, etc.

The problem of child life is only one part of the subject of ante-natal care. Puerperal sepsis, eclampsia, abortion, anæmia and other forms of illness during pregnancy, if treated in time, or if the conditions under which they arise were in view from their onset, could be greatly alleviated. It may be asserted that if all women were under skilled medical observation during pregnancy about half the ante-natal deaths that now take place could be prevented, and the number of premature births could be reduced. Similarly such conditions as atrophy, debility and marasmus are due to ante-natal conditions which might have been controlled or remedied by ante-natal medical attention. Therefore any scheme to be successful should consist of ante-natal clinics held weekly or fortnightly at a recognised place, and house-visiting of pregnant women by women health visitors. It is possible by proper ante-natal care not only to reduce the death roll of unborn infants, and preserve the life of many infants born to die within a week of birth ; but above all it would be possible to preserve the health of the mothers, to save them from prolonged and exhausting labour, and to restore them after confinement to such condition of health as will enable them to perform the duties of motherhood in the best possible way.

Recent experimental and clinical work, specially observations made on the children of mothers who received a defective diet, have shown that the health and well-being of the child may be greatly affected by the diet of the mother, and have thrown a flood of light on the causation of rickets and dental caries in children and on the importance in their prevention of a natural diet for the mother during pregnancy and lactation, containing a sufficiency of vitamins A and D.

An essential part of ante-natal care is to watch the excretory functions of the kidneys and the condition of the blood pressure. The rise of blood pressure is the earliest sign of toxæmia and may precede the appearance of albuminuria, and its early detection will save many mothers from getting eclampsia. Another advantage of ante-natal care is the recognition of the likelihood of the difficulty in labour on account of disproportion, which may be due to contracted pelvis or abnormal size of the child in an otherwise normal pelvis.

The whole position of maternity, both pre-natal and post-natal, demands serious attention from the State, and this not only in its own interest and the interest of the country, but also for the sake of the mothers themselves, most of whom are stricken with poverty, and who should be assured of all the medical skill and nursing facilities that are available to their more fortunate sisters in the higher grades of life.

(*b*) *Natal Period.*—In this country the care of women during parturition is very much neglected; an unused, dark, ill-ventilated and damp room, commonly used as a lumber room, or for keeping domestic animals, like cows, is usually selected as the lying-in room. Instances of death both of the mother and the child from carbon monoxide poisoning during puerperium are not uncommon. This is due to the closing of doors and windows and keeping a charcoal fire in the room. In the majority of cases, the work is done by quack midwives who are absolutely ignorant of even the very rudiments of hygiene and cleanliness. As a result of all this, one of the common causes of death in infants, during the first week, is tetanus neonatorum, and in mothers, puerperal sepsis. Those infants who survive the first week die of bronchitis and broncho-pneumonia. During this period such assistance as may be required should be arranged to ensure the mother having skilled and prompt attendance during confinement at home. This part of the work should be done by trained midwives, the health visitor coming to their aid in cases of difficult labour, or any other condition involving danger to the mother or the infant.

(*c*) *Post-natal period.*—This period is very important, for upon the attention paid at this time depends the health of the mother and the child. Excluding ante-natal conditions, and those arising from the act of birth, the health and development of the child depend upon its environment. Under this are included those factors which directly or indirectly influence and modify physical, mental and moral growth. These factors are hygienic, *i.e.*, all that pertains to air, washing, clothing, housing, etc., and dietetic. Early commencement of household or other work, want of proper food and clothing are responsible for much of the ill-health of the mother. During this period treatment of complications,

whether in the mother or in the child, should be undertaken by the health visitor. Mothers should be instructed in the proper methods of nursing babies, and on the prevention and cure of minor ailments of infants. Most of the ailments of infants are due to improper feeding. In breast-fed infants the cause of the mischief must be sought in the mother; in hand-fed babies the quality, the quantity, or the mode of preparation of food, or the condition of the bottles, may be at fault, and these require careful investigation. The dangers of artificial feeding are especially common during the first few weeks of infant life. After three months the child's digestion acquires a certain degree of stability. It is difficult to assign the mortality to its true cause always, but there is no doubt that improper feeding is the prime cause in a large proportion of the deaths from intestinal disorders, spasmophilia, rickets, etc.

Maternity and Child-welfare Scheme

The Child-welfare Centre.—The establishment of a centre or centres is the first step, but it must be clearly understood that mere establishment of a centre is not the beginning or the end of the whole scheme. It is only the head-quarters from which different parts of the scheme should radiate.

The centre should be in charge of a medical officer who may be consulted by the mother. It should consist of a hall where mothers can congregate with their children. There should be arrangements for weighing and measuring babies, and the hall may be utilised for lectures to mothers, demonstrations, and mothers' meetings. The walls should be decorated with appropriate and instructive diagrams and charts. The chief provision in the centre besides the medical officer of health, will be qualified women health visitors and some trained midwives. The medical officer of health must be selected from those who have made some special study of infant hygiene.

The maternity centre must be prepared to recognise, investigate and treat the various complications and risks incidental to pregnancy. It has also the responsibility to the unborn child, and its duties are not completed until the child is safely born and the mother is wholly and completely restored to a normal state of health.

The general work at the centre should consist of :—

(*a*) The examination of all babies, and, when necessary, their mothers by the medical officer on their first visit.

(*b*) To issue printed leaflets in different vernaculars giving instructions with regard to the hygiene of pregnancy, infant care, preparation of infant food, etc., as also instructions with regard to clothing, exercise and rest, care of the breasts, etc.

(*c*) To weigh all children by a nurse especially trained in child-welfare work.

(*d*) To adopt such measures as will popularise the scheme and educate the public, and to organise popular purdah lectures on the maternity and child-welfare, illustrated with lantern slides, in villages where mothers and expectant mothers can be induced to attend.

(*e*) To hold annual baby shows, and offer prizes for healthy and well-kept babies.

(*f*) To make provision for cheap meals for poor, expectant and nursing mothers.

(*g*) To arrange for hospital accommodation for expectant mothers shortly before and during labour.

(*h*) To supply good cow's milk, and other articles of infant food free, or at cost price to needy mothers.

(*i*) To supply trained nurses for confinement free to the poor, and for a small fee for others requiring help.

(*j*) To introduce elementary hygiene with special reference to child-welfare in all girl's schools.

The medical officer should generally supervise and co-ordinate the whole scheme.

The Health Visitor or Visitors.—An adequate number of health visitors is the essential factor in any scheme of maternity and child-welfare. A tactful and sympathetic health visitor can do much useful work by giving advice to pregnant women in their own houses. They should be qualified medical women, and one wholetime health visitor for every 500 births is the usual average number required for the work. The health visitor should treat minor complaints of infants, and should give directions on general hygiene, preparation of infants' and invalids' food, and explain the dangers of bad ventilation and overcrowding, advise mothers on the management of common ailments of infants and children, and impress upon them the value of breast-feeding. They should help the midwives in case of difficult labour, supervise their work, and pay periodical visits to the houses of infants until they are one year old.

Provision for an Efficient Midwifery Service.—For those who cannot afford to engage the services of a trained midwife the centre should provide the services of a competent midwife gratuitously. Arrangements, therefore, should be made for an adequate supply of trained midwives in each area. In places where competent midwives are not available the centre should make provision for the maintenance of at least one in such places. These midwives should undertake confinement cases either on a small fee or gratuitously as the case may be. Not only in villages, but also in cities like Calcutta, too much of the midwifery is done by quack midwives. These women are a hinderance to any scheme; they are not competent to give proper advice to pregnant women, and during confinement they practically court infection by having absolutely no idea of the elementary

principles of cleanliness, sepsis and asepsis, and do a good deal of harm both to the mother and the infant. Since it is not possible to replace the quack midwives easily, it would be better if these women could be trained in proper midwifery and child-welfare work by inducing them to attend the lectures at the different centres, or special lectures organised for their benefit locally. Proper provision for safe midwifery is essential, and it should be the duty of every one concerned in the child-welfare work to urge on expectant mothers the necessity of engaging a properly trained midwife; and the workers should be in a position to supply such help.

It should be remembered that the establishment of child-welfare centres only will not yield any fruitful results unless the workers, on whom the success of the whole scheme depends, are willing, conscientious and sympathetic. The health visitors and the midwives can help a good deal to popularise the scheme by their kindly manners, genial personality, and readiness to help those requiring help. All this is work for local organisation, but there is a phase of the question which requires direct State help not simply of a financial character.

The Maternity and Child-welfare Act of Great Britain empowers all the local authorities to make arrangements for attending to the health of prospective and nursing mothers and of children under five years. They are to provide *creches* and day nurseries, to establish convalescent homes for nursing mothers and children under five years, to provide home-help and other assistance for securing proper conditions for the confinement of necessitous mothers, and to provide maternity and child-welfare centres with midwives and maternity nurses.

An ideal centre in England consists of a wholetime doctor, four health visitors, a dental clinic, a hospital for most difficult cases of confinement, a centre to which pregnant women can go for advice, and a centre from which food and milk can be distributed under certificate of the medical officer of health to women who are necessitous or who cannot obtain proper food and milk for their condition. The centre possesses a maternity home with sixteen beds and, if used a fortnight by each mother, will provide for 240 women a year.

The duties of medical officers of child-welfare centres may be summarised as follows :—

A. Clinical Duties

1. Pre-natal Clinic :
   (*a*) *Normal Cases.*—Advice on hygienic pregnancy and instructions in the case of infants.
   (*b*) *Abnormal Cases.*—These should be referred to
      (*i*) own family doctor, or
      (*ii*) special hospital, or
      (*iii*) treatment section of the clinic.

2. Post-natal Clinic :
   (*a*) Medical consultation for those who desire the same, up to six weeks after confinement.
   (*b*) After six weeks these consultations to be merged with infant consultation.
3. Baby Clinic :
   (*a*) *New-born infants.*—All babies brought to the clinic for the first time should be examined by the medical officer.
      (*i*) *Healthy and normal infants.*—Mothers to be advised on infant care and management.
      (*ii*) *Abnormal infants.*—To be referred for treatment.
   (*b*) Other infants should be examined by the medical officer and classed as above.

NOTE.—The primary duty of the clinical officers at welfare centres is the prevention of defects and the education of the parents in the early detection of the same.

If any conditions are found affecting either the mother or the infant, which may be attributed to mismanagement or neglect on the part of the obstetrician, he should be notified of the defects discovered.

B. Administrative Duties

1. Procedure to carry out
   (*a*) notification of birth,
   (*b*) treatment for ophthalmia,
   (*c*) control of puerperal fever.
2. Organisation of
   (*a*) health visiting,
   (*b*) supervision of midwives.
3. Co-ordination between

general public health work, maternity and child-welfare work and school medical service.

CHAPTER XXIII

VILLAGE SANITATION

THE question of improving the sanitation in villages is a problem which is engaging much attention at the present moment. An efficient sanitary campaign has to be undertaken before any good result can be expected, and this can only be attained by a concerted action by both the public and the sanitary authorities. Most of the villages are not as a rule controlled by municipalities, but district boards and union boards are responsible for the improvement of sanitation and public health, and in most cases their funds are not sufficient to undertake an elaborate scheme.

For the improvement and development of villages, the Bengal Local Self-Government Act of 1885 (modified up to 1st Sept., 1933) has been passed, which applies to all parts of Bengal not under the control of a municipality.

The insanitary condition of the villages is responsible for most of the deaths from preventable diseases, chiefly malaria and the water-borne ones. This is due mainly to the ignorance of the people about the elementary principles of hygiene, to their bad and insanitary habits which have become almost a part of their nature, and to the general apathy of the educated and the well-to-do, who take no initiative, and very often migrate to towns and other healthy places. As a result of all this the villages are left in a very neglected condition, and the poor are left to take care of themselves. One must realise that without the co-operation of the people, efforts of sanitarians to improve the sanitary condition of villages must perforce be inoperative. The introduction of a Public Health Act, which should make the administration of sanitary law uniform, universal and imperative throughout Bengal, deserves serious consideration.

The creation of a public health organisation for improvement of the health condition in the rural areas is receiving special attention from the Government of Bengal. This contemplates dividing the province for the purpose into units or circles, coinciding with the *thana*; each unit to comprise roughly about 100 square miles. These Rural Public Health Circles, as they are called, will be under a Sanitary Inspector or a Health Assistant, and their work will be controlled by the District Health Officer under the District Board. The primary aim of these health units will be the prevention of disease by securing information of the conditions existing in the area, and to take immediate measures against cholera, small-pox, enteric fever, and other infections that may from

time to time occur in these areas. The health assistant or the sanitary inspector will look to the sanitary condition of the *bazar* or *hat*, attend *melas*, and examine and take samples of food suspected to have been adulterated. They will purify water of tanks and wells when contaminated and carry out disinfection in the case of any infectious disease. They will try to discover the incidence of kala-azar, malaria, tuberculosis, leprosy, and of venereal disease, and adopt measures for the prevention of their spread. Attention will be paid to child-welfare work by training *dais*, and by inspecting village schools to examine the physical condition of the students. Finally efforts will be made to educate the villagers by health lectures, demonstrations, etc., with some knowledge of the elements of hygiene.

Any scheme for the improvement of the sanitation in villages, should embrace the following:—

1. Mass education.
2. Housing accommodation.
3. Provision of a good water-supply.
4. Efficient conservancy.
5. Protection against malaria and other water-borne diseases.

1. **Mass Education.**—This is of primary importance, inasmuch as upon this the efficiency of any sanitary measure depends. No matter how perfect the measures might be, if the people are not educated enough to appreciate the advantages of such measures these are most likely to fail. The people should be convinced that most of the diseases from which the villagers suffer are preventable, and therefore thousands of lives can be saved annually, and that the greater the co-operation the easier the task and cheaper the cost becomes of such prevention. The people can be educated by organising popular lectures, preferably illustrated by lantern slides, and pointing out to them the dangers of insanitary habits. They should be told of the dangers of overcrowding, of dust and disease, of measures necessary to prevent infantile mortality. Easy means of avoiding preventable diseases can very well be illustrated, and the effects of bad ventilation, insanitary surroundings, and pollution of water should be impressed on them forcibly. The different preventive measures should be drawn up in such a manner as will make them easily workable.

A primer in simple language, for the purpose of disseminating elementary knowledge in hygiene may with advantage be introduced in the village schools. The Primary Education Bill of Bengal is calculated to remove some of the defects by making education compulsory to all children.

2. **Housing Accommodation.**—In villages the majority of the houses are huts made of split bamboo plastered with earth and without sufficient provision for proper ventilation.

Cattle and other domestic animals are often kept in the same room where food is generally stored or perhaps cooked. In the construction of these huts the earth is dug out from the neighbouring land, which forms a hollow and eventually becomes filled with dirty water, and forms a breeding place for mosquitoes, and not infrequently this water is used for washing and other domestic purposes. People should be taught to build sanitary huts, and model bustees should be built to set an example.

A description regarding the proper construction of huts in towns has already been given (*see* page 135), but the following details will be found useful in case of villages. Each hut should contain two rooms, a kitchen and a small courtyard surrounded by a wall. Whenever possible there should be a verandah round the hut. It should be built on a plinth at least one foot high. The room should be 15 ft.×12 ft. and 12 ft. high. Each room should have two windows 3 ft.×2 ft. placed opposite to each other and opening direct into the open air. If there is a privy it should be situated at one end of the courtyard away from rooms and kitchen, and built according to an approved plan. The trap-door should be easily accessible and the latrine must be kept clean by daily removal of all excreta. The floor of the huts should be made with some impermeable material, preferably cement plastered.

3. **Water Supply.**—This is another great problem in villages not provided with public water-supply, where consequently water for drinking and cooking purposes is drawn from any source available, such as rivers, tanks, wells, etc., which are usually very highly contaminated from being used for all purposes. Wells are constructed without any regard to sanitary laws, and are sunk too close to privies or drains, and the interior not made water-tight by cement coating, with the result that offensive matter gains admission into the water and makes it foul.

In some parts of India the wells are provided with steps so that people can get direct access to the water, consequently the chances of contaminating the water are great. Moreover, the incidence of guinea-worm infection is in proportion to the number of step wells existing in a place (*see* page 400). No fresh step wells should be constructed and the existing ones should be converted into ordinary draw wells.

Tanks are more liable to contamination than wells owing to the fact that they are less protected, and both men and animals get direct access to the water. Unfortunately in non-municipal areas very little attention is paid to protecting tanks from contamination. The ways in which tanks are polluted are innumerable: people will wash their mouths, bathe, pass urine and stools on the banks, wash clothes, cook-

ing and other utensils, and bathe domestic animals. Privies are often constructed close to these tanks. The result of all these insanitary habits is obvious, and the public should be clearly warned of the dangers of such practices. Some arrange-

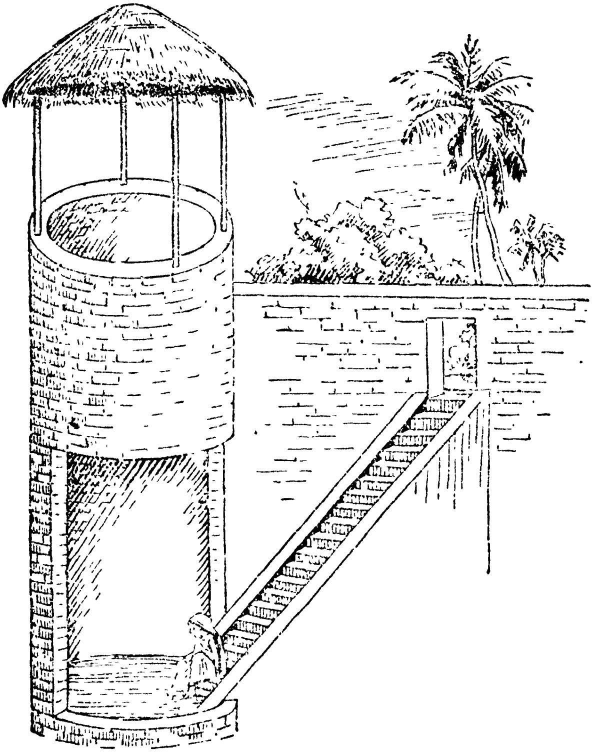

FIG. 152—STEP WELL.

ment should be made for a good water-supply, and one or two model tanks should be excavated and kept under proper supervision to be used only for drinking purposes. Rivers and streams are also open to contamination of all sorts in the same way as tanks, and generally become the public latrine on account of the ablutions customary in them. Thus the germs of cholera and typhoid fever are carried and spread among the people, and it is therefore neither safe nor desirable to drink water from any such sources unless it is purified by boiling. The public, therefore, should be taught the importance of having pure water for drinking purposes and of avoiding drinking water from sources not properly protected against pollution.

The question of providing a supply of pure water in

villages is, therefore, most important. It is neither very difficult nor is it, necessarily, a very expensive matter to provide pure water. Tanks or wells (*see* pages 16 and 23) if properly constructed and looked after should afford supplies of good water at a relatively small cost. Where funds permit, tube-wells may be sunk. These are very convenient, and since there is less chance of contamination, they are well suited for the purpose. The water of large tanks when properly reserved is often so pure as to require no filtration. Ordinary wells constructed with due regard to their surroundings and properly looked after would also afford a reasonably pure water. It is only necessary to emphasise that under no circumstances should private vessels be used for drawing water. Wherever possible pumps should be selected as the only method for drawing water from a well. If this is not possible a metal bucket and chain worked by windlass should be used, the bucket being permanently kept at the well.

For many rural areas, however, all that is necessary is to provide reserved tanks free from human pollution. The water of such tanks would generally be found to be pure and quite safe for use, especially if drawn by a pipe from the centre. The actual provision of pure water, therefore, is not in itself a very difficult question. The real problem is how to provide administrative machinery that would enable Union Boards and other local authorities both to obtain supplies of water and preserve its purity. Cisterns or galvanised iron tanks provided with taps, which are to be filled regularly from the well or tank, would be a great improvement on most village water-supplies. In some places the water from the reserved well or tank could be raised to a height and then distributed by means of pipes by gravitation.

4. **Conservancy.**—This includes removal and safe disposal of human excreta, house and other refuse, slop water, etc. In non-municipal areas there are practically no arrangements for privies or latrines; people generally go to some open land, or use the banks of tanks or rivers for purposes of nature. These are fruitful sources for disseminating different forms of infection. It is almost impossible to stop this habit, inasmuch as people of means and education have recourse to this sort of open air privies. The dangers of pollution of soil and water with human excreta in spreading hook-worm infection and other diseases like cholera, typhoid, dysentery, etc., have already been discussed. It needs only to be pointed out that these are pre-eminently rural diseases due to insanitary habits and should not occur where there is a proper sanitary organisation. Children ease themselves anywhere and everywhere—such as the courtyard, or in or about the house. Arrangements should be made for privies in every house; if this is not possible, public latrines should be constructed in suitable places and people induced to use them.

Where privies exist they are often situated close to tanks or wells, the water of which they pollute not only by soakage but by the washings which are carried directly into the water. Too often these privies are ill-kept and insanitary with ample opportunities for pollution of water through soakage. (*See* Fig. 3, page 23). For attending to the cleanliness of latrines the villagers would do well to engage a *methar* (sweeper). Fouling of the seats is quite common, and if once they are fouled people will not use them, but will pollute the place all round it, not excepting the passage, and so create a nuisance. There should be separate latrines for women—well protected and screened. If these latrines are not possible, bored-hole latrines may be constructed. Trench latrines are quite suitable and inexpensive. A simple method of combined latrine and trenching ground suitable for small communities is to have a plot of land properly fenced and divided into two portions. Each evening a trench is dug in the one division, the earth being piled on the side. The excreta are deposited in this trench and each person is instructed to cover the deposit with enough earth. A sweeper goes round in the evening and covers the dejecta more completely and digs a second trench to be used in the same way the following day. Thus when the whole half portion of the plot is used up, the other half is next used. People should be instructed not to use the tank for ablution purpose—a most common and pernicious habit. Where sweepers are available, arrangements for proper disposal of night-soil should be made.

Disposal of dry refuse is equally important. This consists of food waste, dust, refuse from stables, workshops and shops, dry leaves and flowers. All these undergo rapid putrefaction and give off offensive smell. They should be frequently removed and not scattered about the house or thrown about the road. It is not uncommon to throw all refuse in the back yard where they collect in heaps. This is a very insanitary practice; the refuse undergoes decomposition and gives off offensive gases, breeds flies, and during the rains the polluting materials are washed away and contaminate tanks, etc. The flies are the greatest carriers of diseases like cholera, typhoid fever, diarrhœa, etc., and their breeding should be checked. The refuse, therefore, should be properly disposed of. There are two practical ways of disposal of garbage, *viz.* to bury it or to burn it. In small places, burial is a very good method. The pits should be just big enough to hold a pail of refuse which is then covered with three to four inches of earth on the top, and a new site selected for each successive pail. It may also be utilised in reclaiming low lands, hollows (*Dobas*), or in the preparation of compost (*see* page 233). But they create a serious nuisance if not properly carried out and if located

near to the road side or to dwellings. They must be covered with earth or rubbish from dismantled houses.

The night-soil and refuse may be disposed of together in a more sanitary way by incineration. This is possible where there is organised labour under proper control and sufficient combustible material in the refuse. When the refuse consists of dry leaves, wood, etc., it may be utilised to supply the necessary inflammable material. A small incinerator will be found quite efficient for the purpose. This type was extensively used with success during the war under the name of "Beehive Incinerator." It is easy to construct, easy to manage, and would burn quite an enormous quantity of refuse.

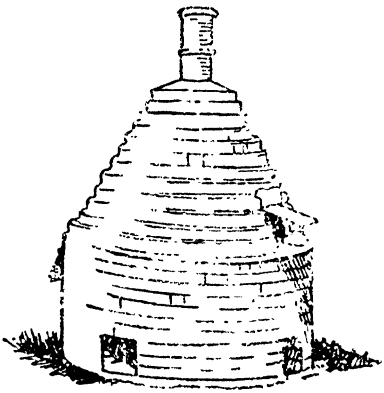

FIG. 153.—BEEHIVE INCINERATOR. (From the Official History of the War).

It is built with a subterranean air space for draught, a central air cone, and at the level of the top of the air cone, and close to it, a perforated tray for burning fæces. The walls are made of brick, stone or similar material cemented together with a mixture of clay and cow-dung.

The subterranean air space gives just as good a draught as any other, and with an open air cone above its centre produces a draught when inflammable material such as, wood, paper, etc., are being burnt. A zone of intense heat is produced immediately around the air cone on which the perforated tray for fæces rests. The night-soil is rapidly dehydrated and charred and ultimately catches fire. The openings allow the liquid excreta, etc., to percolate through on to the bed of the fuel and refuse beneath which absorbs them. In the zone above the air cone, gases and smoke arising from the burning and destructive distillation of the contents are burnt, and what escapes from the funnel is practically only steam which is soon dissipated into the surrounding atmosphere.

If funds permit the night-soil may be disposed of by constructing what is known as a "Dumping Septic Tank." By suitable arrangements, provided there is sufficient supply of water, the night-soil may be carried and allowed to pass into a septic tank.

A modified form of water-carriage system for the disposal of sewage on a small scale can be arranged in public institutions, clubs, tea gardens and by well-to-do people in the mofussil, who have sufficient fund at their disposal. Such an

arrangement is shown in figure 154 constructed by the National Reinforced Concrete Co. of Australia, which works well and is very popular. All that is required is an arrangement for flushing the water closet by having the water stored in a overhead reservoir by a hand pump. The sewage is then carried by stoneware pipes to a small household septic tank built on the same principle as described on page 280. It

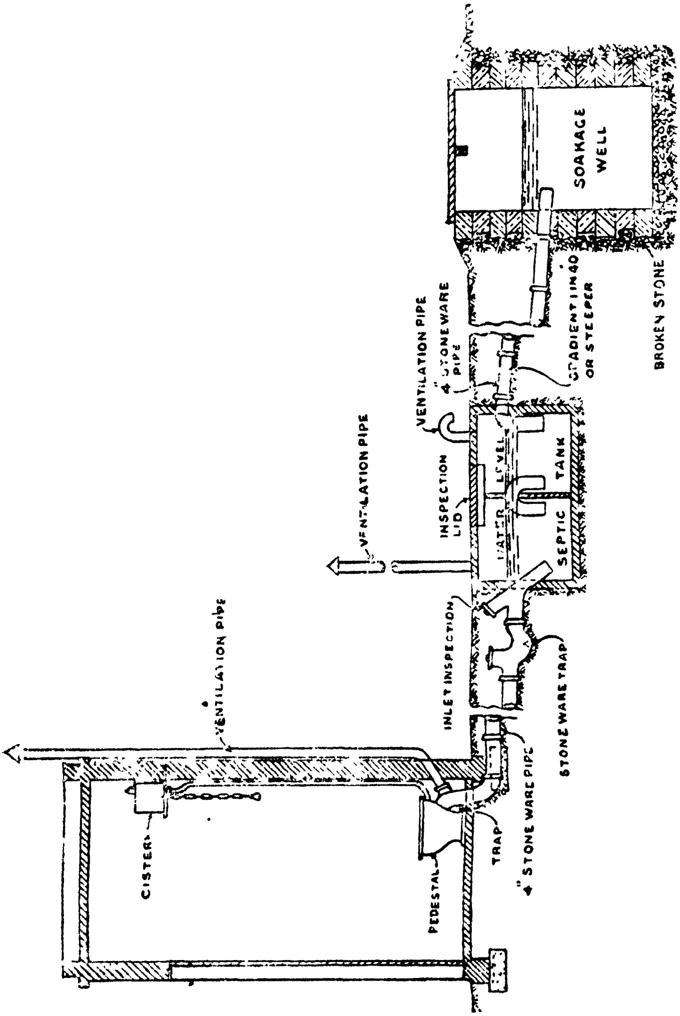

FIG. 154.—DOMESTIC SEWAGE DISPOSAL BY HOUSEHOLD SEPTIC TANK.
(From Sewage Disposal in India and the East by Bransby Williams).

should consist of two chambers the first compartment serving the purpose of a grit chamber in the septic tank latrines *(see fig. 154)*, the effluent is then carried to a soakage well, which may be conveniently built away from the house on

some open land. This well is not permissible near to a well or tank from which water is drawn for drinking purposes, nor where the soil consists of impermeable clay, but may be built where the subsoil is comparatively porous. It is a simple and effective method of getting rid of the final effluent.

The removal of slop water, rain water and other liquid filth is generally effected by surface drains in both municipal and non-municipal areas. Ordinarily these are inefficient, ill-kept and are no better than dirty offensive puddles. They have no proper gradient, and during the rains they become full of foul liquid which undergoes decomposition and putrefaction giving off an offensive smell. These drains are no better than elongated cesspools, and not being made of any impervious material, they act as sources of pollution to the neighbouring tanks and wells through percolation. In most instances weeds and other plants grow on the sides and beds which materially impede the free passage of water. A proper system would be as follows :—

1. Drains constructed with a proper gradient, and made impervious with cement or glazed half-channelled pipes.
2. They should be cleaned periodically and all weeds and plants removed.
3. They should not lead or open into any tanks or any other sources of water-supply.
4. They should be disposed of by irrigation over agricultural lands and away from any human habitation.

Disposal of the Dead.—Both man and animal when dead require to be disposed of properly. In villages dead animals are simply thrown away on the road or on some open land near about the house, where they undergo putrefaction and give off most offensive smells, while dogs and jackals carry them about creating a great nuisance. Dead bodies are burnt anywhere and everywhere, or thrown into the river and sometimes buried in the house. These are most insanitary practices and prejudice the health of the pepole. It is therefore necessary that some rules should be observed with regard to all dead bodies. Burning of the dead should be allowed only in some fixed places allotted for the purpose. It should be well protected from outside and no one should be allowed to throw dead bodies or half-burnt bodies into the water. Where there is a river, burning should be done on its bank and only burnt ashes may be thrown into the water. Clothes, bedding, etc., should not be scattered about but burnt with the dead. If cremation is done near a tank, the tank must be kept separate and the water should not be used for drinking purposes. (*See* Disposal of the Dead, page 298).

5. **Protection against Malaria.**—The reduction or suppression of malaria in villages is of vital importance, inasmuch as the majority of malaria infection occurs in villages.

Although the broad principles for preventing the disease are the same whether one has to deal with cities, towns, cantonments and villages, yet the details by which these are carried out are not identical. The mass of people living in the villages are not only poor but are ignorant of the very rudiments of sanitation. Measures, therefore, to prevent mosquitoes from biting by having mosquito-proof houses, fans or punkhas, or by the use of culicides cannot be so freely and universally adopted. Reduction can only be effected by case-reduction in villages, and by measures which will reduce the number of anophelines in and around them. It is, therefore, necessary that the *rationale* of our present day prophylactic measures of malaria should be widely circulated and made known. In every village, persons capable of understanding the primary principles of prevention should be held responsible for the carrying out of the preventive measures, and villagers should be impressed with their importance through them. *Travelling dispensaries* in charge of medical officers will serve a very useful purpose in distributing quinine and giving relief to the villagers, especially during the malarial season. The people must be taught to help themselves and once they can be made to realise what "water-tidiness" consists in, elimination of the offending larvæ will be a comparatively easy task. The public should realise the true significance of water-tidiness, and water should not be allowed to be collected in rejected vessels, broken tin boxes, etc., and shallow pools should be filled up. Instructions regarding the main facts connected with malaria should be given by popular lectures, and illustrated leaflets, in the vernacular of the place, circulated. The value of cinchona alkaloids as a prophylactic and the use of mosquito nets should be forcibly impressed on the public, and the prejudice against quinine, which so widely prevails, even amongst men of education, should be removed by all reasonable means. When quinine is distributed amongst the masses, it must be done through some responsible person, who should see that it is actually taken and not thrown away, as is often done, by the ignorant villagers. The elementary principles of sanitation may be incorporated in text-books for children. Besides the above, the following special measures recommended by Hehir are of great value:—

1. The treatment of all cases of malarial fever and malarial enlargement of the spleen with quinine.

2. The making of surface drains (even *kutcha* drains) properly graded for removing rain water and refuse water generally.

3. Covering of all sources of water-supply with some mosquito-proof material.

4. The filling up of all borrow pits and other excavations in and around villages for a distance of at least 100 yards.

5. The prevention of all cultivation within this 100 yard limit and of wet cultivation within 200 yards.

6. The keeping of this 100-yard area and the interior of the village free from mosquito larvæ.

7. Jungle and shrub should be cut down and burnt for a distance of 100 yards around the village.

General principles of prophylaxis against water-borne diseases:—

(*a*) All discharges, fæces and urine, in which the organisms of disease are found are to be destroyed or disinfected as rapidly as possible.

(*b*) Flies are the principal carriers of these germs and therefore food, milk, and water should be properly protected against flies. Kitchens should be made fly-proof. Flies breed in refuse and these should be properly disposed of.

(*c*) Since it is possible that apparently healthy persons may also harbour disease germs, it is important that all excreta should be satisfactorily dealt with.

(*d*) Water-supplies, milk and other food should be protected from the possibility of contamination by the so-called carriers.

(*e*) Boiling of water and milk, and thoroughly cooking other articles of food liable to be contaminated.

(*f*) Preventing washing of clothes and other utensils in or near a tank or well.

(*g*) Setting apart a tank for drinking purposes only, and not allowing washermen (*Dhobies*) to wash dirty and infected clothes.

(*h*) Preventing milkmen from using dirty water for cleaning pails and other utensils, or mixing suspicious water with milk.

(*i*) Using *bleaching powder* to sterilise all suspicious waters of tanks or wells.

That the general health of a place can be materially improved by proper sanitary organisation is amply illustrated from the reports of the Mines Board of Health at Asansol in Bengal. A place once the hot-bed of disease the population of which was being annually decimated by a regular succession of epidemic diseases, chiefly cholera, small-pox and malaria, has been transformed into a most salubrious area of its size in the plains of India, with a death-rate which compares favourably with that of many countries in Europe.

CHAPTER XXIV

SANITATION OF FAIRS AND RELIGIOUS FESTIVALS

THE sanitation of fairs *(melas)* and religious festivals in India, though very important, is a complicated task. Every time that a fair or a *mela* is held or there is a religious pilgrimage, it is followed by an epidemic of water-borne diseases, chiefly cholera. Thus in some important places of pilgrimage, *e.g.*, in the *Kumbh melas,* which take place every twelve years and where millions of people congregate, epidemics of cholera occurred regularly from 1867, except 1891, when there was only a very mild epidemic. Places for pilgrimage in India are many ; some are of a permanent nature, while others are temporary. Permanent centres are places possessing special religious sanctity, and which attract quite a large number of pilgrims all the year round. These are Hardwar, Benares, Muttra, Brindaban, Puri, Kalighat in Calcutta, and Tarkeswar in Bengal. In temporary centres pilgrims assemble in large numbers at certain times of the year only. Thus during a bathing festival people congregate by thousands along the banks of the sacred rivers which afford sufficient opportunities for pollution of water and spread of disease. Figure 155 shows how an Indian river is being used for bathing purposes during such a festival.

Abundant evidence is now available to show that these congregations of people, either in the different pilgrim centres or in the different *melas* and fairs, are frequently responsible for the outbreak and spread of diseases disseminated by close personal contact, by contamination of food and water, and by the agency of flies.

The organisation of sanitary control sufficient for the wants of ordinary pilgrim traffic in the many permanent centres is not so difficult. But efficient sanitary oversight during special *melas* or festivals, which take place at recurring intervals is a very difficult problem and cannot be so easily managed. Since different fairs vary greatly in style and character, it is not possible to formulate fixed rules that will apply to all such places under all conditions. Sanitary measures called for must perforce depend upon the local conditions. In every case a regular plan of work should be drawn up and arranged previously. The site should be marked out, and the whole area divided into isolated plots and each such plot placed in charge of one or more sanitary officers, who should see that the latrines are kept clean,

that the lodging houses are free from any sickness and kept in proper order. The number of carts, sweepers, scavengers and the inspectors necessary must be calculated beforehand on the basis of the approximate number of people likely to be present. All lodging houses should be registered and the number of lodgers to be accommodated in each fixed.

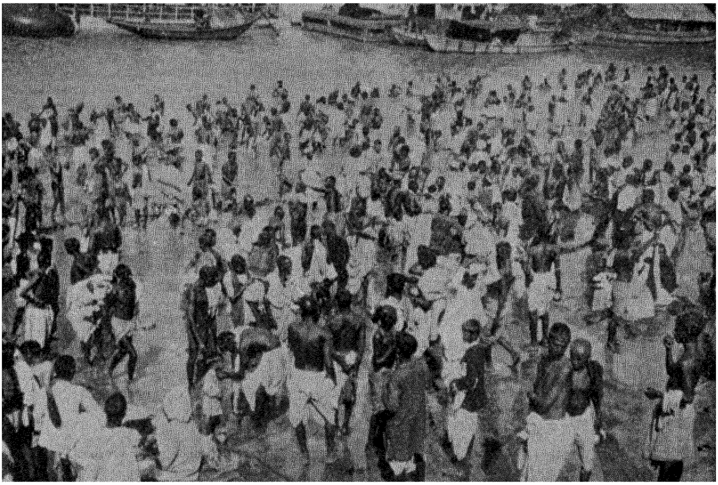

FIG. 155.—AN INDIAN RIVER DURING A BATHING FESTIVAL.

Ventilation, drainage, cleanliness, water supply and privy accommodation for each should be inspected, and unless satisfactory, a license should not be given. At the same time rules should be drawn up, regarding the management of the lodging houses, the number of persons to be accommodated, the cleanliness of the premises, protection of the water supplies, and prevention of nuisance, etc. For the control of the lodging houses special temporary legislation under the Epidemic Diseases Act in respect of cholera, small-pox, etc., or registration in the form of a special Act on the model of the Puri Lodging Houses Act should be incorporated in the Public Health Act.

For the efficient control during these fairs and *melas* the following points require careful attention, *viz.*—

1. Accommodation.
2. Medical and sanitary arrangements.
3. Water supply.
4. Efficient conservancy.
5. Pure and wholesome food.

For carrying out of the above measures the following conditions are necessary, *viz.* (*a*) some persons or body of

persons should be responsible for the organisation and control of the fair or mela; (*b*) adequate executive staff for inspection and other sanitary work; (*c*) rules for the control both of the staff and the pilgrims attending the fair should be drawn up and enforced; (*d*) funds should be provided for the payment of the staff and the carrying out of the sanitary measures.

1. Accommodation.—The management of the lodging houses for the accommodation of the pilgrims has been detailed above. But the site where the fairs should be held requires some attention. The land selected should have natural drainage, well shaded and watered, and laid out previously and kept ready before the arrival of the first batch of pilgrims.

The whole area should be cleared of jungle and dense vegetation and the approach road metalled or otherwise made firm. The land between the main roads should be divided by cross roads, and the space between any two cross roads should be taken as a section of the fair. In case of large fairs there should be a second broad road for the returning pilgrims. The place should be carefully marked out and provision made for the accommodation of officers-in-charge, the police, the hospital, the booths, residential blocks and latrines. Facing the main roads on either side will be the booths, and behind these will be blocks reserved for residence of pilgrims. A strip ten feet wide should be left along the breadth on opposite side of each block as a sanitary area for urinals, etc.

All shallow depressions, pools and back waters should be filled up or fenced in.

2. Medical and Sanitary Arrangements.—Every fair shall be under the medical and sanitary charge of the Medical Officer of Health in whose jurisdiction it is held. The sanitary officer should look for any case of infectious disease occurring in or near the fair.

The whole area should be divided into blocks and each block placed under the charge of a sanitary inspector, who shall daily inspect the area under him and report the occurrence of any suspicious case of illness; arrangement being made to receive daily reports from the sweepers in charge of each latrine of any case of unusual diarrhœa or any similar disease.

For the removal of the sick, stretchers or *doolies* should be provided at the fair hospital and also at the police outpost, and gangs of bearers kept in readiness to carry patients. Unless there is a permanent hospital or dispensary, every fair must be provided with a temporary general hospital and an isolation hospital. They may be conveniently placed in one of the side roads away from the main road and preferably on an open land.

For the accommodation of infectious cases temporary huts may be erected, one for male patients, and one for female patients, with quarters for the medical officers, servants, etc. Latrines, with wooden seats and iron or earthen receptacles, should be close to the wards. All the dispensaries should be equipped with prescribed standard drugs and stores, stretchers, *doolies*, disinfectants—such as hycol, cyllin (*see* p. 431), and vessels for boiling water, etc.

3. **Water Supply.**—An efficient arrangement for the supply of wholesome water for drinking purposes is of utmost importance, and since the pilgrims are generally affected with water-borne diseases, every source of supply must be kept under proper supervision to prevent improper use and contamination. In places where filtered water-supply is not available deep tube wells should be provided whenever possible. In the absence of these, a sufficient number of masonry wells or reserved tanks should be constructed, at the same time all temporary or *kutcha* wells should either be closed or treated with bleaching powder. Some arrangement should be made for drawing water from wells and indiscriminate use of other vessels strictly forbidden. The wells should be disinfected with chloride of lime a few days before the commencement of the *mela*. If there are a sufficient number of tanks already in existence, a few may be selected and reserved for drinking purposes, and no one should be allowed to wash on the banks or bathe in these tanks. The above precautions should also be observed in case of rivers, where such exist, to protect the water from pollution. Every morning and again in the evening some sweepers should patrol the banks of the rivers to remove all filth.

Good water may also be provided by arranging some galvanised iron cisterns or tanks fitted with taps, filled regularly from some reserved tanks or wells, or with filtered water when available.

Burning ghats should be located well down the stream beyond the fair limits.

4. **Efficient Conservancy.**—A proper arrangement for efficient conservancy is as important as the supply of good drinking water. It is, therefore, necessary that an adequate staff of properly paid sweepers should be employed. The whole gang should be divided into groups in charge of a mate and every sweeper must bear a numbered badge and provided with quarters near his work. Female sweepers should be employed for latrines meant for women.

The sites for latrines must be previously selected and their construction supervised by the sanitary inspector. In the construction of the latrines the following points should be attended to :—

(*a*) They should not be too far away, or else the people will not use them.

(*b*) No latrine should be more than a hundred yards away from the fair limit.

(*c*) The inhabited site of most fairs should be laid out in rectangular blocks and behind each one or two blocks the latrines should be situated.

(*d*) In the fairs where the people visit daily but do not live there, at least two seats for every 1000 people may be taken as the average.

(*e*) For pilgrims living within the area of the fair, one seat for evey 100 persons may be taken as a fair average.

The type of latrine best adapted is a *trench latrine.* (*See* page 243). A trench forty feet long, ten to twelve inches wide and eighteen to thirtysix inches deep is convenient. The person using the latrine will squat with one foot on each side of the trench. The earth is pulverised and kept behind the trench leaving a space about six inches along the border of the trench for the foot rest. Movable screens are placed both in front and at the back of the trench behind the accumulated earth. By placing screens three feet wide across the trench separate compartments are easily made, each screen being three feet away from the next. By a partition placed in the middle, each forty feet trench is divided into two sections and each section should accommodate seven seats.

When the first trench is filled up the screen in front of it is removed and placed behind the second one and in this way as many trenches as are required may be utilised.

In place of trench latrines arrangements may also be made by placing earthenware vessels (*gamlas*) on the ground with two bricks forming the foot pads. The ground should be hollowed out where the receptacles are placed. These latrines may be arranged in rows of twenty with bamboo matting partitions, and provided the receptacles are regularly cleaned as soon as they are used these will be found to be quite satisfactory (*see* Temporary Latrines, page 246).

Urinals should be located at the corner of each block of the inhabited side of a fair. In ordinary soil a pit four feet square and five feet deep filled with broken *jhama* four feet deep should be made and at each corner of this pit, a kerosene tin full of sawdust with a perforated bottom is placed soaked in perchloride of mercury (1 in 500).

Every latrine must be constantly kept in a state of cleanliness and should be properly lighted at night. To prevent people from using places other than the latrines, the approaches should be kept scrupulously clean, all vegetation and high crops near about the fair previously cut down and removed. The night-soil should afterwards be removed in proper receptacles or night-soil carts for disposal. The method of disposal will depend upon the local conditions, and may be done either by burning or by trenching.

Satisfactory arrangement for the removal and disposal of all refuse should be made. Therefore there must be sufficient number of refuse carts, dustbins and wheel-barrows. The refuse may either be dumped in a place previously prepared for the purpose, or incinerated. Temporary incinerators of the "Beehive" pattern or open incinerators will serve the purpose quite satisfactorily. A description of the closed Beehive incinerator will be found on page 575. Although the burning of solid excreta in an open incinerator is not theoretically satisfactory, it was found quite efficient during the last war and may with advantage be utilised during fairs as a temporary measure.

5. **Food Supply.**—Arrangements should be made for the supply of pure and wholesome food at a reasonable cost. The sanitary inspector should examine the milk, fish and other foods, and should see that these are kept in a cleanly condition. Unwholesome food, over-ripe fruit and decaying vegetables should be strictly forbidden. If these are discovered they should be seized and destroyed as a preventive measure.

The last Kumbh mela was held in the year 1930 and lasted for about one month from January 14th to February 13th, where millions of people assembled at Allahabad to bathe in the river Ganges, specially where it joined the river Jumna. The river at Allahabad recedes about a mile during winter and it was at this dried up river bed that accommodation for 100,000 pilgrims was made with serried rows of tents, huts and other temporary shelters.

The whole mela area was divided into eight sanitary circles, and each circle was placed in charge of a medical officer who had under him two or more sanitary inspectors, four vaccinators, four jamadars, one cooly for disinfecting duties, besides sweepers and mates according to requirement. There were also two or three *domes* for collecting corpses and for the disposal of unclaimed dead bodies.

For the disinfection of wells in the mela area there was a separate unit of eight *kahars* under one sanitary inspector.

One main hospital with 100 beds was provided for the treatment of general diseases. Branch hospitals were provided in each mela circle and one additional hospital for the Police with ten beds in each. There was in addition one first aid station in each circle and stretcher squads at the various railway stations and at suitable places in the mela area. One main infectious disease hospital with 100 beds and two branch hospitals with 10 beds in each were provided for the segregation and treatment of infectious cases. Besides another hospital was put up by the Municipal Board in that part of the city where a large number of lodging houses were situated.

Most of the pilgrims were inoculated against cholera at

the station of departure and steps were also taken to inoculate in the mela area against cholera and typhoid, and to vaccinate against small-pox.

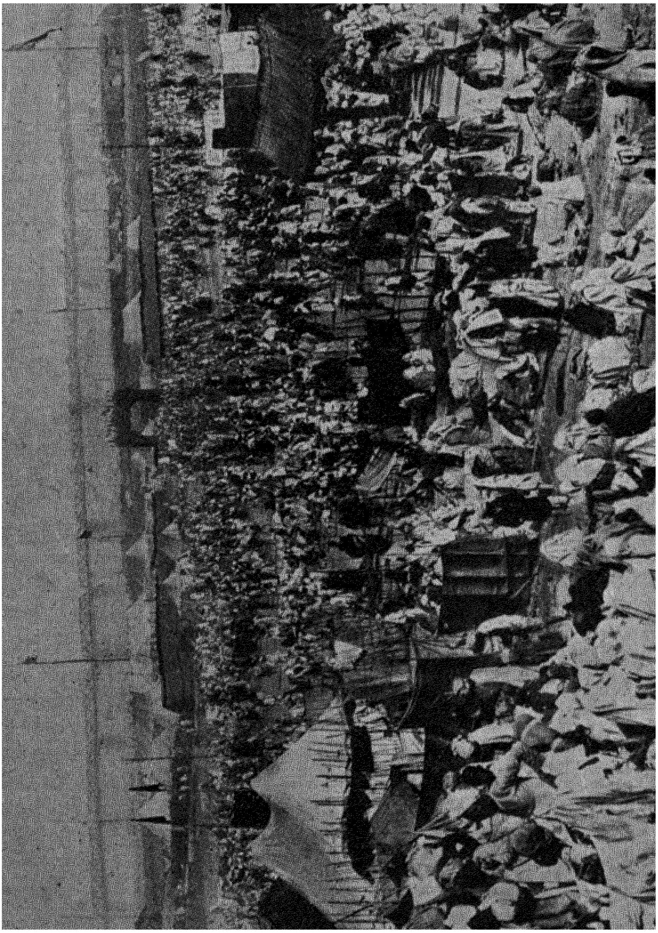

Fig. 156.—A Corner of Kumbh Mela.

Sanitary Control of Hedjaz Pilgrimage

The pilgrimage to Mecca is enshrined in a halo of romance and has always been of great interest to the different nations of the world. For the last fifty years the sanitary problems connected with the pilgrimage have been recognised as being of great international importance. Because in the first place, the sanitary conditions are very unsatisfactory, and are beyond the reach of direct European

supervision ; in the second place, the places are the seat of annual concourse of several thousands of people from all parts of the Moslem world, in some of which cholera and plague are endemic; finally, immediately after the festival there is rapid and widespread dispersal of the pilgrims to different parts of the world. Situated as it is, the Hedjaz, in fact the whole area surrounding the adjoining Red Sea, has on several occasions in the past proved the corridor by which various infectious diseases have spread from East to West as also from West to East. At least on one occasion cholera introduced into Mecca by pilgrims from the East, was carried to Egypt whence it spread almost throughout Europe, invaded England and reached New York. Consequently ever since international sanitation became the subject for discussion between the nations of the world, and it has been realised that special precautions should be adopted with reference to all the Red Sea traffic and specially the Mecca pilgrimage.

Certain measures for the sanitary control of the pilgrimage are prescribed by the International Sanitary Conventions of 1926. Although the Government of India has not yet ratified the Convention, it is generally agreed that it would be in the interest of India to ıatify it.

The main countries from the East from which pilgrims travel are India, Burma, the Malay States, the Netherlands, East Indies and China. They may travel overland, but as generally happens most of the pilgrims travel by the sea.

From the year 1882 onwards pilgrim ships coming to the Hedjaz have been required to put in at Kamaran island near the southern end of the Red Sea, to be dealt with in accordance with the provisions of the successive International Sanitary Conventions. It was administered by the Constantinople Board of Health, on behalf of the Ottomann Government until June 1915, when the island was occupied by the British Government. After the war the island passed into the hands of the Government of India, but since Holland was equally interested in the regulation of the pilgrim traffic, because of the large number of Mahommedan pilgrims from the Dutch East Indies, an Anglo-Dutch agreement was signed in 1926. This agreement will be in force for eight years and embodies in its schedule the measures laid down in part III of the International Sanitary Convention including the control of that traffic at Kamaran.*

The principles of the agreement are (1) to protect the

* For further information consult Report of the Haj Inquiry Committee, 1931, Government of India; Report on the Inquiries into the measures for the Sanitary Control of the Hejaz Pilgrimage, 1919, by Lt. Col. E. Wilkinson.

interest of the various territories, outside the Hedjaz, through which pilgrims must pass ; (2) to co-ordinate arrangements for the transport of the pilgrims from one country to another with the maximum of comfort ; (3) to avoid repetition of the sanitary and quarantine measures, inoculation, etc., imposed on pilgrims *en route*.

The following are important requirements of the agreement :—*Art.* 3. Anti-smallpox vaccination and two anti-cholera inoculations are obligatory and are carried out in the country of origin within six months of the date of departure. Anti-plague vaccination depends upon the epidemiological circumstances in the countries of departure and of transit. Every pilgrim must be furnished with a "pilgrimage card." *Art.* 4. The card must show, *inter alia*, the photograph or finger print, the rank of the pilgrim, the route followed, the vaccination performed, etc. *Art.* 5. The "pilgrimage card" will be delivered by the country of origin or elsewhere by the Consuls of that country. Before delivery the pilgrim must produce a return ticket and deposit a guarantee. These may be waived if the country of origin accepts full responsibility for the cost of the voyage. *Art.* 7. The transit by land route of pilgrims who do not fulfil the conditions required, *e.g.*, who only had one anti-cholera inoculation, will be effected by convoy under surveillance, but measures applied to foreigners will be no more severe than those for nationals. *Art.* 9 *and* 10 refer to the definite route which pilgrims from the various countries must follow.

CHAPTER XXV

VITAL STATISTICS

VITAL statistics may be defined as the science of numbers applied to the life-history of communities. The general state of the public health in every country depends largely on the measure of adjustment of the relation of the individual and the race to the environment; the more complete and continuous the adjustment the greater being the longevity. Of the problems of life with which the science of vital statistics is concerned the following are of special importance, *viz.* population, birth, marriage, sickness and death.

A thorough enumeration of the population as well as the registration of births and deaths according to their causes and at different periods of life form the natural basis of vital statistics. But it is necessary to explain that the vital statistics of India are of a defective character. There is no record of marriages and an inadequate one of sickness. Registration was first introduced in India in 1863, but the difficulties encountered have been great. The people, doubtful of the object, do not like to make their domestic affairs public. The statement of the causes of death leaves much to be desired, as many die without being attended to by a qualified medical man, and all cases of death accompanied by a rise of temperature are attributed to "fever." Moreover, during an epidemic the real cause of the disease is often concealed in order to escape sanitary measures.

To improve the registration of births and deaths, that is, to bring vital statistics up to a desired standard, the local authorities should insist on having a daily record of all deaths registered at the burial-grounds and burning ghats and compare these with those aleady reported at their office for registration. In cases of deaths not reported the authorities should take suitable action against the defaulters as provided by the Acts. In the case of births, measures should be taken to force the householder, or the parents, or to induce the midwives or *dais* to report all births within a fixed period (usually seven days). The vaccinators as well as the outdoor municipal staff should enquire about all such events during their rounds and report to the authorities any cases of omission for proper steps.

It is of great importance that the registration of births and deaths should be accurately kept, inasmuch as the facts derived from such registration are of great value in determining not only the numerical changes in the population, but also the extent of mortality and its causes. The cumula-

tive effects of the various health factors on the vitality of the population is shown in the variation in the birth- and death-rates. The registration of vital statistics is done throughout British India except in the most remote and backward tracts.

In England births must be registered within 42 days, and deaths within 5 days; the latter must be accompanied by a certificate of death signed by a registered medical practitioner. Births must also be notified to the M.O.H. within 36 hours, this is for a sanitary purpose so that the Health Service may get in touch with the mother and child and endeavour to give them the benefit of Maternity and Child Welfare Centres.

In India the registration of Births and Deaths Act of 1873 when applied makes the registration of births and deaths compulsory. Where applied, the local authority must appoint a registrar or a sub-registrar, who must keep himself acquainted with vital happenings in his area and should institute legal action against delinquents. As a rule this act is only applied in municipalities, and is very feebly enforced.

Under the Calcutta Municipal Act of 1923, deaths should be registered by medical practitioners in attendance within 3 days and in hospitals within 12 hours. As a matter of practice, most of the registration is done by sub-registrars at burial grounds and cremation grounds. In other municipalities the 1873 Act applies. In rural areas, the 1873 Act may be applied by the District Magistrate or the information about births and deaths collected in any way directed by him. The chowkidar reports to the police or to the President of the Union Board, who passes on the information to the District Health Officer, who then submits his monthly report to the Director of Public Health, who in this respect corresponds to the Registrar General of England. The Director of Public Health, Bengal, estimates that birth and death returns are short by 27 per cent. and in some districts the omissions, especially as regards births, are much higher, reaching sometimes 50 per cent.

In India the first census was taken between 1867 and 1872 and was repeated in 1881 and subsequently at intervals of ten years, and the last was taken in March 1931. The value of these enumerations has been very great, although the return of ages is by no means accurate, since the majority of people being illiterate cannot furnish correct statements of age and occupation. But the figures enable us to make an approximate estimate of the true birth- and death-rates and of the mortality by age and sex, and afford data for the construction of a life-table.

The following table gives the population of India at the various censuses since 1881 and the rate of increase :—

		Rate (percentage) of increase based on the previous census population
1881	253,896,330	
1891	287,314,671	13.16 p.c.
1901	294,361,056	2.45 p.c.
1911	315,156,396	7.06 p.c.
1921	381,942,480	1.20 p.c.
1931	352,837,779	10.63 p.c.

Estimation of Population.—The population figure is the denominator in estimating death-rates and birth-rates. The accuracy of these rates will therefore depend on the accuracy of the estimation of the population. As the population varies every day throughout the year, the mid-year population of July 1st is the one adopted for estimating birth- and death-rates. The census is taken usually on 1st April, so that this even does not give us the required figure. There are various methods of estimating the mid-year population, none are absolutely correct and all are approximations. The method selected for a particular place should be that one which by experience has been found to give most approximate results as checked by the actual census figures. In India some municipalities endeavour to estimate mid-year population year by year, but most (*e.g.*, Calcutta) simply take the last census figure for calculating birth- and death-rates. As the intercensal period progresses and the population is meanwhile increasing, the estimated birth- and death-rates are too high, and this mistake gets greater as the intercensal period progresses.

Estimation of population is generally done by the following methods :—

1. If a strict record of emigration and immigration be kept then in a country in which a complete registration of births and deaths is enforced the population can be ascertained by balancing the *natural increase* by excess of births over deaths and increase or decrease due to migration.

This method has proved fairly reliable in England and Wales for the country as a whole, for births and deaths are known and the differences in any year (natural increase) accurately determined. Figures for immigration and emigration are also now available and are regularly published. Estimations of populations by this method for the whole country are therefore possible but informations of population movements within the country itself are usually not available and the method is therefore not applicable to towns and districts.

Thus the Registrar General of England and Wales was able to predict the 1931 census figures within 0.9 p.c.

margin of error. In India, for the 1931 census, India born persons living outside India were estimated to be $2\frac{1}{2}$ millions and foreign-born persons living in India to be less than a million. The Public Health Commissioner in India recommends that for calculating the yearly inter-censal populations in provinces, the method of natural increase should be used.

2. The increase of inhabited houses in a district being known the increase of population may be estimated on the assumption that the number of persons per house is the same as in the last census.

Average number of persons per house

	1931	1921	1911	1901	1891
India	5.0	4.9	4.9	5.2	5.4
Bengal	4.7	5.1	5.3	5.2	5.2

3. Another method is by calculating from the average birth-rate of the last ten years. It is worked out by the following formula :—

$$P = \frac{\text{Registered birth in the year} \times 1000}{\text{average birth-rate for the last ten years}}$$

Thus, if the birth-rate of a town for the ten years (1910-1919) was 30 per 1000, and the actual number registered in 1920 was 450, then the population for 1920 will be according to the formula $\frac{450 \times 1000}{30} = 15{,}000$

Therefore the estimated population for 1920 is 15,000.

4. *Estimation by Arithmetic Progression.*—This is based on the assumption that the increase in population in an intercensal period is constant from year to year and proceeds by arithmetic progression, *i.e.*, there is an equal addition to the population every year ; and further that this same rate is applicable to the years following any intercensal period.

Thus if the census population on 1st April

1911 was	... ...	25,000
and in 1921 ,,	... ...	30,000

the increase in ten years was 5,000, and the average yearly increase was $\frac{5000}{10} = 500$.

To find the mid-year (1st July) population of 1925. This is $4\frac{1}{4}$ years from 1st April 1921.

The mid-year population of 1925 is therefore $30{,}000 + 4\frac{1}{4} \times 500 = 30{,}000 + 2125 = 32{,}125$.

This method has been found to give fairly correct results for certain rapidly growing towns of America.

5. *Registrar General's Method.*—This method assumes also that the rate of increase is constant, and is the same as existed during the previous intercensal period of ten years. The rate of increase however is not considered arithmetical but geometrical; that is, each increase of population in one year contributes its share of increase during the following year (like money accumulating by compound interest).

Thus, if P = population of any census year,
R = annual increase per unit of population, *i.e.*, per person.

Then one person becomes $(1+R)$ at the end of 1 year; and P persons become $P(1+R)$.

At the end of the second year $P(1+R)$ persons become $P(1+R) \times (1+R) = P(1+R)^2$.

At the end of the 10 years they become $P(1+R)^9 \times (1+R) = P(1+R)^{10}$.

At the end of n years become $P(1+R)^n$.

If P' = population required
then $P' = P(1+R)^n$

To solve $P' = P(1+R)^n$ logarithms are made use of

$$\log P' = \log [P(1+R)^n]$$
$$= \log P + \log (1+R)^n$$
$$= \log P + n \log (1+R)$$

by transposing we get

$$n \log (1+R) = \log P' - \log P$$

$$\therefore \log (1+R) = \frac{\log P' - \log P}{n}$$

This gives us the log of annual increase for a known intercensal period. If we wish to estimate population at the present moment, we assume that the annual rate of increase has remained constant and proceed as follows:—

Let us take P'' as a sign for the present year which we wish to estimate

then $P'' = P'(1+R)^n$
and $\log P'' = \log P' + n \log (1+R)$

or $\log P'' = \log P' + n \dfrac{\log P' - \log P}{10}$

Example:

The population of a town at the census of 1901 was 32,000, and at that of 1911 was 36,000; find out the population for 1920.

log pop. 1911 = log 36,000	= 4.5563025
log pop. 1901 = log 32,000	= 4.5051500
difference = log of *ten* years' increase	= 0.0511525
divide by 10 = log of *annual* increase	= 0.0051152
multiply by 9	= 9
Product = log of 9 years' increase	= 0.0460373
add log pop. 1911 = log 36,000	= 4.5563025
∴ log pop. 1920	= 4.6023398

But 4.6023398 = log 40025.8
∴ pop. for 1920 = 40025.8

This gives the estimated population as on April 1st. To get the estimated figure of mid-year population $9\frac{1}{4}$ years increase is required and the log of annual increase should be multiplied by 9.25 and *not* by 9.

This method was devised by the Registrar General of England and Wales and is found by experience to give good approximations of population increase in towns of England and Wales. It is therefore the method usually adopted there.

6. *Method by using the Number of Registered Electors.*—Under any system of franchise the number of registered electors has usually a definite relationship to the population number. The number of electors naturally changes from year to year. If the franchise system is not altered, however, the number of registered electors in any year could be used to calculate the population of that year.

Example: In 1921 the census population on April 1st was found to be P and the number of registered electors R. If R′ is the number of registered electors found in the books in 1928 then $\frac{P}{R} \times R'$ would give the estimated population of the town on April 1st 1928.

Birth-rate.—An accurate registration of births is as necessary to the sanitary statist as an accurate knowledge of population obtained from the census. Statistics based on the birth-rate calculated on the total population, are of value in considering the progress or decline of a community in a series of years. Strictly speaking, they are not a correct record of the fecundity of the people, as they depend not only on the number of births and adults producing offspring but also on the number of young and old persons, who contribute nothing to the increase of the population. Births are usually reckoned at a rate per 1000 of population. The *annual* birth-rate of a community is calculated according to the following formula :—

$$\frac{\text{number of births in one year} \times 1000}{\text{mean population.}}$$

Example:

There were 250 births in a year out of a population of 10,000; find the annual birth-rate for the year.

According to the formula we have $\frac{250 \times 1000}{10{,}000} = 25$ births per 1000.

The birth- and death-rates may be calculated from weekly, monthly or quarterly returns.

A *weekly* birth-rate =

$$\frac{\text{number of births during one week} \times 52.17747 \times 1000}{\text{Mean population}}$$

A *monthly* birth-rate =

$$\frac{\text{No. of births in month} \times 365.24226 \times 1000}{\text{Mean population} \times \text{No. of days in month}}$$

N.B. Note that monthly and weekly birth-rates are really *annual* birth-rates, based on the assumption that the particular number of births in any particular month or week were to occur in all the other months or weeks in the year.

Causes affecting Birth-rates :

1. *Marriage Customs.*—These undoubtedly play an important part in India as marriage is a religious obligation with most Indians. Here polygamy is permitted, widowers may remarry, but not widows as a rule. Marriage usually takes place at an early age and there is a disparity in the ages of husband and wife ; and, as a consequence, an excessive proportion of widows.

Among the Mahommedans, Buddhists and Brahmos the age of females at marriage is generally higher and the disparity in the ages of husband and wife is less. There is also less restriction on widow remarriage.

2. *Agricultural Distress or Prosperity.*—The birth-rate is sometimes a barometer of prosperity ; with a marked rise or fall in food prices there may be similar movement in the death-rate and an opposite movement in the birth-rate nine months later.

3. *Normal Seasonal Variations.*—Seasonal variations have an influence on the birth-rates. In Bengal the largest number of births take place in January and the minimum in August. Most provinces in India exhibit similar phenomena.

A more scientific method of stating the birth-rate, than that of the reckoning of annual births to 1000 of the population, will be to calculate the proportion of births to every 1000 women of conceptive age, *i.e.*, between the ages of 15 to 45 years. This is called the "corrected birth-rate."

The crude birth-rate is calculated as all the births, both legitimate and illegitimate. Separate rates for legitimate and illegitimate births are sometimes calculated.

Falling birth-rates have been a recent feature in all civilised countries. In 1876, the English crude birth-rate was 36.3, since when it has declined steadily, being now less than half that figure (12 in 1932). Most modern countries show a similar decline. The birth-rate (recorded) in India was 34 in 1932, this was a fall on the two previous years. The influence of high birth-rates on economics, disease and war has been the subject of close study ever since Malthus wrote his celebrated Essay on Population. Malthus held that the pressure of a growing population on the food supply resulted in "checks" to a population's increase by war, pestilence and famine. Intelligent and civilised man refuses to accept these checks as inevitable and instead uses his intelligence to avoid them. Increased production of the food supplies in the world, interdependence between nations in food and manufactured articles and "birth control" are some of the results of economic pressure on intelligent communities. By birth

control it is meant to include increased celibacy (decrease of the marriage rate), later age of marriage, and limitation of families by voluntary abstention from intercourse, and the use of contraceptive methods for avoiding pregnancy. These are some of the causes of the decrease of the birth-rate in Western countries, but others (Carr Saunders) would add other causes, such as lessened fertility due to increased affluence and rise in the standard of living, etc. In certain provinces in India, *e.g.*, Bengal, investigation would appear to show that birth-rates are falling. The subject has very important bearings on the future constitutions of the nations of the world, but is too complex to admit of further consideration here.

Still births are not counted either as births or deaths, but are recorded separately.

Death-rate.—Death-rates are calculated in the same way as the birth-rates :—

$$\text{The annual death-rate} = \frac{\text{number of deaths in one year} \times 1000}{\text{mean population}}$$

Although the registration of deaths in India is defective the recorded rates are generally very high. This high death-rate is due to the fact that India suffers more than Europe from epidemic diseases like cholera, plague, small-pox, etc., which have practically disappeared from places where sanitary methods have reached a certain level of effectiveness. The general death-rate of a population is taken as the test of the sanitary condition of the place.

The sensitiveness of Indian death-rates to sanitary conditions is remarkable and their fluctuations are greater than those among European populations. This sensitiveness may be attributed to several causes, *viz.*—

1. The high birth-rate, infantile mortality forming a large proportion of the general mortality and being notoriously sensitive to sanitary conditions.

2. The early marriage of all girls, which causes the population to breed up to its means of subsistence, and renders it easily and extensively affected by want.

3. The high death-rate, which is more easily and largely affected by favourable conditions than a low death-rate, and conduces to a low mean age for the population.

In addition to the different epidemic diseases, India not only suffers from some of the most serious diseases of temperate climates, but has a long list of infectious diseases special to the tropics.

Specific Death-rates.—The death-rates for different age-periods, both for males and females (say from 0 to 1 year, 1 to 2, etc.) can easily be calculated and especially accurately in a census year. They are called specific death-rates. They

can be plotted out on a curve which assumes the form shown on figure 157.

It will be seen that the specific death-rates are high at the extremes of life and that the healthiest periods of life are between 5 and 35 in England and between 10 and 15 in India. Male death-rates in England (except for the period 10 to 15 when the female death-rate is slightly higher than the male) at every age-period are higher than the female rates. A consideration of the curve of the specific death-rate will

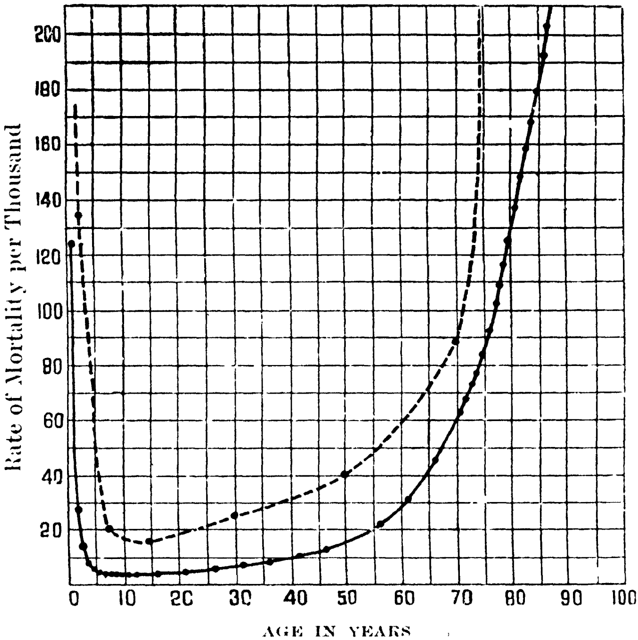

Fig. 157. Specific Death-rates of England and India (dotted line).

indicate at what particular age problems of health mostly arise. In England, for instance, the high death-rate from 0-5 and after 35 years of age are matters of concern and we find at present the problems of Maternity and Child Welfare, and children's diseases, receiving special attention, and with later years cancer, heart affections and respiratory affections. In India obviously every age-period at present requires special attention.

The specific death-rates may also be used to illustrate the progress of a population of say 100,000 persons born at the same time progressing through life, and showing the number alive at the end of each year. Such a table for England and India could be constituted as follows :—

LIFE TABLE

England and India 1901 –1910. (Number of survivors at different ages)

Age	England	India
0	100,000	100,000
1	85,566	75,000
5	79,398	55,000
10	78,083	50,000
15	77,297	45,250
20	76,113	41,250
25	74,546	40,000
30	72,741	36,125
35	70,472	31.600
45	64,230	23,000
55	54,435	15,000
65	39,278	8,100
75	19,754	2,600
85	4.349	400
95	149	0 ?
05	2	0

It will be seen that half the children born in India die before they reach the age of ten, a tremendous waste of national substance and energy.

Crude death-rates are summations or integrations of specific death-rates applied to the number of the population of a particular place in the different age groups. It must be distinctly remembered, however, that the crude death-rate is *not* obtained by adding together the specific death-rates. The specific death-rates must be applied to the different numbers of the age groups, the deaths added and the crude death-rates thus obtained.

In order to obtain a perfect idea of the death-rate in a given population or community the total number of deaths in each sex in proportion to the number of the living should be stated. In regard to sex, while the estimated death-rates during 1911-1920 at all ages in Bengal are 31.7 and 30.5 per mille for males and females respectively, there is a notable contrast in the relative incidence of mortality on the 10-34 age-periods and the rest of life. The female death-rate amongst children under one year is lower than the male, but this gradually diminishes until the age of 6 or 7 is reached. From this age the female death-rate begins to increase—the highest being reached at 15 to 20, after which the difference diminishes until at 35 it disappears and thereafter the female rate remains lower. The highest number of deaths among females occurs during the child-bearing period. (*See* table page 605).

The following table gives the average number of female

births and deaths per 1000 male births and deaths for two decades :—

Province	Births		Deaths	
	1921	1931	1921	1931
Bengal	933	922	909	944
Bihar & Orissa ...	950	962	936	921
Bombay	925	923	957	942
Burma	945	956	901	916
Central Provinces ...	955	957	923	922
Madras ..	956	953	979	979
Punjab	906	970	928	885
United Provinces ...	919	891	918	876

Death-rates obtained from mortality returns of short periods, *e.g.*, a week or a month, are not to be depended on as tests for health, as they are liable to accidental fluctuations. The same is also the case with death-rates of very small populations even if returns for a year be made. Weekly death-rates, however, are very useful in comparing mortalities in a town in any week with the corresponding weeks of the previous year. Any rise in mortality should lead to an enquiry ; and warning may be got of the commencement of a serious epidemic of small-pox, cholera, or influenza or other disease.

Weekly and monthly death-rates are calculated in the same way as weekly and monthly birth-rates (*see* page 594).

Combined death-rate means the total death-rate of a combination of two or more districts, and is estimated from the ratio which the two or more populations bear to one another.

To find out the death-rate of a combined district where the death-rates of the individual districts are known, the following calculations are made, *viz.*—

Let A = population of one district,
x = its death-rate per 1000,

then $\frac{x \times A}{1000}$ = total deaths in A.

Let B = population of another district,
y = its death-rate per 1000,

then $\frac{y \times B}{1000}$ = total deaths in B.

Therefore $\frac{x \times A}{1000} + \frac{y \times B}{1000} = \frac{Ax + By}{1000}$ = total deaths in combined district (A + B) ;

and $\frac{Ax + By}{1000\ (A + B)}$ = death-rate per unit in A + B ;

and $\frac{Ax+By}{A+B}$ = death-rate per 1000 in A + B.

Thus if A has a population 5000, B of 10,000 with a death-rate of 20 and 15 per 1000 respectively, then the death-rates of the combined districts with a total population of 15,000 would be as follows :—

$$\frac{Ax+By}{A+B} \text{ becomes } \frac{5000 \times 20 + 10000 \times 15}{5000+10000} = 16.6 \text{ per } 10,000.$$

Corrected and Standardised Death-rates :

Corrected for Residence.—Strictly speaking, death-rates being ratios, the person whose death is being recorded should appear in both numerator and denominator ; that is, his death should be referred to the place where his presence was recorded in the last census. A person from Barrackpore, for instance, going to Calcutta for an operation and dying there should have his death referred to Barrackpore though it would be registered in Calcutta. Such transfers in England are made by the Registrar General, in India by the health authorities. The "Crude Death-rate" thus treated becomes a "Death-rate Corrected" for residence. The term "Recorded" death-rate is applied in England to this correction of residence.

Standardised Death-rates.—It is well-known that the death-rates under five and over fifty-five years of age are higher than the combined rate for all ages, whilst between five and fifty-five they are lower. Hence the death-rate will be raised in a town having an undue proportion of infants and old people. Again, at nearly every age-group the death-rate of females is lower than that of males ; hence an excess of females in a population or town will lower the death-rate. It is therefore necessary that some correction should be made in the death-rate of a town or district for any such disproportionate distribution of age and sex, before its rate is comparable with that of another town or district. The term "Standardised Death-rate" is applied to this adjustment. "Corrected and adjusted for age and sex" would be a good description of the Standardised Death-rate. There are two main methods of standardising the death-rate : the Direct Method, and the Indirect Method.

Direct Method.—In this the common standard to which the the death-rates are referred is the "Standard Million Population of England of 1901." From the census figures of 1901 (which of course give the number of persons of both sexes in England at the different ages), 1,000,000 people, both males and females, are grouped in each period in the proportion in which they were found in the 1901 census.

The following is the composition of the Standard Million :—

All groups	Males	Females	Persons
0	57039	57223	114262
5	53462	53747	107209
10	51370	51365	102735
15	49420	50376	99796
20	45273	50673	95946
25	40835	45998	86833
30	35590	39156	74746
35	31803	34153	65956
40	27591	29302	56893
45	23364	25001	48365
50	19560	21297	40857
55	15295	17064	32359
60	12618	14764	27382
65	8682	10676	19358
70	6009	7713	13722
75	3477	4654	8131
80	1603	2356	3959
85+	552	939	1491
All ages	483,543	516457	1,000,000
	Total 1,000,000		

Other populations have been suggested on an International basis but the 1901 standard million of E. & W. has been retained by most workers, as it has been used for many years now and a change of standard population would involve recalculation of all the standardised death-rates that have been calculated up-to-date. The standard million of 1901 has the disadvantage, however, that it contains a high proportion of persons between 20-25, at which age the English death-rates are very low. To apply this method we must know the specific death-rates of the place whose crude death-rates we are standardising. The specific death-rates are obtained from the registers of deaths which give the age and sex of the deceased. In applying these, the specific rates for males and females should be applied to the number of males and females making up the standard million. A shorter way would be to apply the specific death-rate of persons (both sexes) without regard to sex, to the "persons" population making up the standard million, but this would not allow for sex differences in the standard population. The first method is therefore the correct one.

The method of application is simple and an example is given below :—

Methods of Standardising Death-rates

Direct Method

Age Groups	Standardisation of "Persons" Rate					
	Males			Females		
	Standard Million Population 1901	Recorded Death-rates per Million	Deaths in Standard Million population	Standard Million Population 1901	Recorded Death-rates per Million	Deaths in Standard Million Population
0	57039	47676	2719	57223	39887	2282
5	53462	3575	191	53747	3626	195
10	51370	2036	105	51365	2194	113
15	49420	2988	148	50376	2666	134
20	45273	3829	173	50673	3272	166
25	40835	4458	182	45998	3814	175
30	35590	5954	212	39156	4624	181
35	31803	8221	261	34153	6561	224
40	27591	11185	309	29302	8599	252
45	23364	15259	357	25001	11373	284
50	19560	21490	420	21297	15813	337
55	15295	30399	465	17064	22458	383
60	12618	44938	567	14764	32423	479
65	8682	60779	528	10676	44585	476
70	6009	98509	592	7713	75312	581
75	3477	142303	495	4654	112926	526
80	1603	194465	312	2356	162852	384
85 and up	552	281549	155	939	242502	228
All ages	483,543		8,191	516,457		7,400

$$\text{Death-rate (persons)} = \frac{8191 + 7400}{483543 + 516457} = \frac{15{,}591}{1{,}000{,}000}$$

or 15,591 per million.

Indirect Method.—This method is designed to save labour and to give a standardising factor at the beginning of each intercensal period which when applied to crude death-rates during the following censal period of ten years will at once give a standardised death-rate. It gives results closely approximating to the direct method and is now largely used in England and Wales. It has the disadvantage that the standard rates during one intercensal period are not strictly comparable with those of previous intercensal periods, though the Registrar General of England has attempted to get over this by using the standard million population of 1901 as a common base.

The method is applied by taking the specific death-rates of the community for a censal year when they are accurately known and applying these to the age and sex distribution

of the town under consideration. An "Index Death-rate" is thus marked out for the town.

Take the case of a town with a population of 10,000 at the census of say 1901. Distribute the population according to age and sex into the twelve age-groups (as in the table below) as per figures obtained from the census returns, and apply to the population of each age-group and each sex the death-rate for that particular age and sex obtained for England and Wales generally during the last intercensal period of ten years, and calculate the number of deaths which each such rate produces, thus ;

Take the males at ages 0.5, *viz.*, 562. The death-rate for England and Wales for males at that age period being 62.7 per 1000, the total number of deaths amongst the population of 562 will be $\frac{562 \times 62.7}{1000} = 35.23$. Again in the next age group, *i.e.*, between 5-10 years with a death-rate of 4.3 per 1000 means $\frac{4.3 \times 534}{1000} = 2.3$ deaths among 534 males of that age-group. Calculating in the same way for each age-group and each sex it will be found that the total deaths will come up to 174, that is to say there would have occurred 174 deaths or $\frac{174 \times 1000}{10000} = 17.40$ per 1000 among a population of 10,000 persons at the same rate as obtained in England and Wales generally. This rate of 17.40 per 1000 is known as the *index death-rate*.

Age period	Population divided for age and sex (1901 Census)		Death-rate (E. & W.) (1891-1900)		Calculated number of deaths.	
	Male.	Female.	Male.	Female.	Male.	Female.
0-5	562	571	62.7	52.8	35.23	30.16
5-10	534	547	4.3	4.4	2.29	2.40
10-15	513	520	2.4	2.6	1.23	1.35
15-20	496	506	3.8	3.7	1.88	1.97
20-25	etc.	etc.	etc.	etc.	etc.	etc.
25-35						
35-45						
45-55						
55-65						
65-75						
75-85						
85 and upwards						
Totals.	4873	5127			83	91
	10,000				174	

The Index Death-rate is merely a hypothetical one and

is calculated on the assumption that the deaths in a town or district occur at the same rates as in England and Wales generally, in the different age periods.

Having applied the England and Wales death-rate at each group to the population of the town or district the *index death-rate* for the place thus obtained ought to be the same as in England and Wales, other things being equal. But this is not actually the case as the rate of mortality for England and Wales during the ten years of 1891-1900 was 18.2 per 1000; hence the age and sex distribution of the town or district are obviously different from that of England and Wales. The *index death-rate* must therefore be raised in the following proportion to make it comparable with that of England and Wales.

$$\frac{\text{rate for England and Wales}}{\text{index death-rate}} = \frac{18.2}{17.4} = 1.045.$$

The factor for correction for that particular town or district is 1.045. Now if the general (*i.e.*, the recorded or crude) death-rate for any year be multiplied by this factor the *standardised death-rate* is obtained. Therefore Standardised D. R. = General D. R. $\times$ Factor. Suppose, for example, the crude death-rate of a town for 1910 was 16.5, then the standardised death-rate for that year would be $16.5 \times 1.045 = 17.24$. If the correction factor is *greater* than *one*, it means that the age and sex distribution of the town is favourable to low mortalities, that is, as compared with England and Wales it has a larger number of people at ages with low mortalities. If *less* than *one*, the distribution is favourable to high mortality.

It is generally found that the age and sex distribution, remains fairly constant—except in big and important industrial towns—during an intercensal period. For this reason the factor is calculated once in every ten years—the last factor holds good until a fresh factor is calculated from the next census.

Comparative Mortality Figure.—This is a useful means of expressing a comparison of the death-rates of different towns or districts. For any year it is

$$\frac{\text{the standardised death rate} \times 1000}{\text{death-rate of E. and W. for that particular year.}}$$

For instance, the death-rate for England and Wales for 1905 was 15.2 and the standardised death-rate for a town was 17.24, therefore.

$$\text{the C. M. F.} = \frac{17.24 \times 1000}{15.2} = 1134.$$

This number "1134," is the *Comparative mortality figure* and is the corrected death-rate for the town compared with the death-rate of England and Wales, taken as 1000. It

means the number of persons which in 1905 produced 1000 deaths in England and Wales produced 1134 deaths in the particular town after correction for differences in age and sex distribution.

It may be noted here that the statistical figures are never so accurately and studiously worked out in India as in England and Wales.

Relation between Birth-rate and Death-rate.—It is generally held that a high birth-rate is a direct cause of a high death-rate owing to the great mortality among infants. The death-rate at ages under 5 is three times as high as that of all ages together, and a high birth-rate by producing an excessive proportion of persons of tender years will cause a high general death-rate. But the mortality falls if the high birth-rate were to continue longer, for then the proportion of the total population at ages of low mortality would be increased and the general death-rate lowered.

The following table gives the death-rate per mille at different age-periods amongst males and females in Bengal.

Age.	Average of Period. 1918-1920		Average of Decade. 1911-1920.	
	Males.	Females.	Males.	Females.
0-5	135	128	125	116
5-10	20	17	17	14
10-15	16	15	12	11
15-20	23	25	17	19
20-40	27	29	20	22
40-60	42	36	35	32
60 & over	88	72	81	67

Infant Mortality.—The infantile death-rate is usually calculated as so many deaths under 1 year of age per 1000 registered live births in the year.

Infantile mortality has been steadily falling in most countries since 1881. The decline between the period 1881-1885, and 1900-10, being 25.6 p.c. in France, 15.8 p.c. in England, 23.7 p.c. in Switzerland. Studies of the statistics show that there is a close correlation between the infant mortality rate and the size of the family, owing to two distinct sets of factors, *viz.*, physical and economic. On the one hand the vitality of the mother, and through her the life of the child appears to be affected by the age at which the child-bearing begins, the number of pregnancies and the spacing of births; on the other hand the health of the infant is intimately associated with the circumstances frequently associated with large families, *viz.*, poverty, congestion, malnutrition, insanitary surroundings and the ignorance of the parents.

Other things being equal, infantile mortality gives an index of the sanitary condition of the place as well as of the density of the population. One noticeable feature of its statistics is that it is higher among male than among female children. It is a known fact that male infants are more delicate and more difficult to rear than female infants.

The heavy mortality amongst infants is partly ascribed to immaturity and ignorance of the mother, to improper feeding, to exposure of infants to all insanitary surroundings wherein the causes of malaria, small-pox, measles, bowel complaints, and tetanus abound. Although a large proportion of deaths is due to premature birth and debility, there is no doubt that many are also due to ignorance and neglect; for the death-rate among infants of the poorer classes attended by the Corporation midwife is only 55 per 1000 during the first seven days. (*See* "Maternity and Child-welfare").

Infantile mortality rate or I. M. R. is calculated as follows:—

$$\text{I. M. R.} = \frac{\text{Death under 1 year} \times 1000}{\text{Registered live births}}$$

It there were 600 births registered during the year, and 75 deaths among the infants under 1 year, then the infantile mortality rate should be 75 deaths per 600 births or $\frac{75}{600}$ deaths per birth or $\frac{75 \times 1000}{600} = 125$ deaths per 1000 births, *i.e.* I. M. R. = 125.

The student should appreciate one or two of the fallacies that may be hidden in the infantile mortality figure. Errors in both numerator and denominator may give unreal values. If any deaths of infants are not registered the infantile mortality rate will be too low. Errors in age of the child or infant may give too high or too low a figure. A child of 18 months may be entered as under one, and included erroneously in the infant deaths, and *vice versa*. Deficient registration of births will reduce the denominator and thereby increase the mortality rate. In the case of women who may live in industrial centres and go to their village for confinement, the birth will be registered in the village and not in the town. In a few weeks, however, the mother and the infant return to the town where the latter may die. Such deaths give an appreciably higher infant mortality rate, as the birth is not in the denominator. This happens in Bombay, where the infantile mortality rate may be thereby abnormally high.

The following table gives some comparative figures of birth, death and infantile mortality rates :—

Country	Birth-rate per mille 1932	Death-rate per mille 1932	Infantile death-rate per 1000 births. 1932
India	33.7	21.6	169
England & Wales ...	15.3	12.0	65
Scotland	18.6	13.5	86
New Zealand	17.1	8.0	31
United States of America ..	17.4	10.8	58
Australia	16.9	8.7	41
Canada	22.4	9.9	73
Union of South Africa ...	24 3	9.9	69
Federated Malay States ...	34.0	18.5	139
Egypt ...	44.8	26.8	160
Palestine	44.9	20.7	170

Density of Population.—The density is usually expressed as so many persons to a square mile (in rural areas) or an acre (in towns). This has an important bearing on the death-rate and exercises a great influence on the population. The greater the density the higher the mortality. Farr states that the death-rate increases with the density of population, not in direct proportion but in proportion to the sixth roots of the contrasted populations. But this rule does not hold good in places like England where sanitary conditions have reached a certain degree of perfection. It is only when the density, *i.e.*, the number of persons in a room exceeds a certain limit that its bad effects are manifest and Farr's rule holds good.

Increased density of population usually means pollution of air, water and soil, and rapid and easy spread of infectious diseases. There is also greater filth, crime, drunkenness and other excesses. In India increased density in country districts may be beneficial to public health by removal of waste lands and increase of cultivated areas. In towns people enjoy certain advantages as regards prompt removal of refuse and supply of pure and wholesome drinking water, which are usually denied to those who live in villages. In rural areas the density of population hardly affects the health or mortality. But in towns this has an injurious effect on health. (*See* Overcrowding, page 133).

Although somewhat smaller than Great Britain, Bengal has more inhabitants than the British Isles.

The following table gives the densities of various localities in India in 1931, according to the census :

Delhi	1001	persons per square mile.
Bengal	646	„
United Provinces ...	456	„
Bihar & Orissa ...	454	„
Madras	328	„
Punjab	238	„

Burma	... ...	63 persons per square mile.
Beluchistan	... ...	9 ,,

Occupation and Mortality.—Occupation exerts a certain amount of influence on the health and mortality of the people. In order to make correct statistics showing the influence of occupation on mortality, the number and the age of those engaged in each calling and the corresponding number of deaths should first be ascertained, and the mortality is then calculated from the deaths taking place in each particular occupation. This has been very successfully worked out in England but not in India. Roughly speaking the mortality is comparatively high among workers in cotton, jute or paper mills, or in the manufacture of mineral acids, poisonous metals, etc., or among those whose occupations necessitate constant exposure to sun and rain and to changes of weather. Sedentary occupations have a deteriorating influence on health.

Some occupations require strong and healthy persons, and due allowance must therefore be made for the age at which such occupations are followed. For purposes of comparison the death-rates among those employed at corresponding age periods must be taken.

The occupation mortality of various occupations may be compared with the mortality of all occupied males between the ages of 25 and 65. Taking this figure as 1,000 the following table gives the corresponding mortalities in England for various occupations :—

Clergymen	...	561
Agricultural labourers	...	688
Doctors	...	1021
Coal miners	...	1034
Brewers	...	1346
Stone masons	...	1390
Barmen	...	1955
Tin and copper miners	...	4355

Special Death-rates.—It is important to know the rate of death from different causes. It has been stated that "the causes of death in a death register are necessarily little more than the more or less trustworthy guesses of a large body of more or less skilled observers." If this statement applies to England, where certificates of death are required, one can well imagine how things stand in India where the majority of people die without proper or rational treatment, and where no such certificates are insisted upon.

In India for statistical purposes deaths are classified under the following heads :—

1. Cholera.
2. Small-pox.
3. Plague.
4. Fevers : malaria, enteric fever, relapsing fever, measles, kala-azar and other fevers.
5. Dysentery and diarrhœa
6. Respiratory diseases.
7. Injuries $\begin{cases} \text{Suicide.} \\ \text{Wounds and accidents.} \\ \text{Snakes and wild beasts.} \end{cases}$
8. All other causes.

The following table shows the actual number of deaths from different diseases and the average annual rate per mille of each sex in Bengal :—

Disease.	1919.		1920.		Ratio Per 1000 1920.	
	Males.	Females.	Males.	Females.	Males.	Females.
Cholera	67,601	57,348	29,762	24,437	1.3	1.1
Fever	639,036	590,221	593,523	550,898	25.5	25.0
Small-pox	20,468	16,542	20,013	16,177	0.9	0.7
Plague	288	136	46	20	0.002	0.0009

It is important that the causes of death should be entered according to the official nomenclature, and that the remote rather than the proximate cause should be stated. Thus death from diarrhœa or dysentery in a case of kala-azar should be returned as death from kala-azar.

The registration of sickness for the general population is not feasible although it has been effected in certain companies, societies, and institutions like jails, etc. According to Farr's estimate, two persons are constantly sick for every annual death which occurs, *i.e.*, for one death there are two years of severe sickness. The sanitary officer would be in a better position to deal with preventable diseases, if information of the occurrence of every case, whether fatal or not, were supplied to him, as he could then inquire into the causation of all such cases. It is important that a correct estimate of the number of persons invalided by sickness should be kept, as well as the actual number of deaths.

Life Tables.—We have seen that the specific death-rates are really the measure of mortality in any community ; and that a very good idea of the sanitary conditions of a place may be obtained by a study of the curve of specific death-rates. Specific death-rates may be used in another way. We may start with, say 100,000 individuals, supposed to be born at a particular time and trace them from year to year. At the end of the first year a certain number will have died and this number will depend on the specific death-rate in the first year of life for the community at the particular time. To the survivors at the end of the first year and commencing the second year we apply the specific death-rate of the second year of life, and so obtain the number of survivors beginning the third year, and so on we continue applying the appropriate specific death-rates from year to year until our imaginary population all die. If opposite each year of life we put the number of people alive at the beginning of that year, we have the beginning of what is called a *Life Table.* It is, as will be seen, a purely hypothetical table, showing how a population would die out under certain

conditions, assuming that there is no addition of new individuals to it, and that the specific death-rates at a particular period of time continue unchanged throughout the existence of our imagined population of 100,000 individuals. This last assumption we know is not true by any means, though at certain ages and in certain classes of communities the specific death-rate may not alter very materially during a generation of individuals. But for many classes of persons and ages it is not by any means true.

Life tables are mainly used by Life Insurance Companies, because they give the *average* number of years that an individual at any age may expect to live, and so will determine the average price of an annuity. This "Expectation of Life" as it is called, has been used as a sanitary index, because if the specific death-rates at any age or ages are decreasing, it is obvious that there will be more survivors at the end of these particular years and the expectations of life beyond these ages will be increased. A table of expectations of life at birth in various countries is given on page 613. But the sanitarian will learn more from a close study of specific death-rates at different ages than from a life table. But various health authorities use the expectation of life largely in their reports, so that the student of public health must be familiar with the elements of a life table. In constructing a life table certain conventional expressions and symbols are used.

x, expresses any particular year: the year following would be $(x+1)$, and the year following that $(x+2)$, etc.

m_x, expresses the *individual* specific death-rates in any particular year, and are obtained by dividing the number of deaths in that year (or the average number over a series of years) by the estimated mid-year population. These are usually called the central death-rates.

l_x means the number of persons of our hypothetical population living at beginning of a particular year x.

d_x, expresses the number of people dying in any year x, out of the l_x people who started alive in the year.

l_{x+1} then must be $l_x - d_x$.

q_x, expresses the *probability* of any single person among the l_x dying within the year x. It is obviously equal to the ratio $\frac{d_x}{l_x}$. It is not therefore quite the same as the specific death-rate of the year (m_x) which is the number of deaths divided by the mid-year population. It is necessary to express q_x in terms of m_x thus :—

If we assume that deaths in any year x occur equally distributed throughout the year then the mid-year population will be the number who started alive at the beginning of the year, less half the number of deaths.

Thus m_x by definition $= \frac{d_x}{l_x - \frac{1}{2}d_x}$

divide both numerator and denominator by l_x

and we get $m_x = \frac{\frac{d_x}{l_x}}{1 - \frac{d_x}{2l_x}}$, but by our definition $\frac{d_x}{l_x}$ is q_x.

Therefore $m_x = \frac{q_x}{1 - \frac{1}{2}q_x}$ and from this we get $q_x = \frac{2m_x}{2 + m_x}$

p_x is the probability of any person of l_x *living* at the end of the year and is obviously equal to $1 - q_x$.

Therefore $p_x = 1 - q_x = 1 - \frac{2m_x}{2+m_x} = \frac{2 - m_x}{2 + m_x}$

Having thus from the various values of m_x made a column of p_x for all age periods of one year's interval and starting with 100,000 individuals at birth in our column l_x, we complete the l_x column by multiplying the number living at the beginning of the year by p_x. Thus l_0 is 100,000; l_1, is $(100{,}000 \times p_0)$; l_2 is $l_1 \times p_1$ and so on for the various years until there are no more living.

From the l_x column we make another column L_x, which is based on the assumption that people who died between ages x and (x+1) lived on the average 6 months. Thus L_x would be found by dividing the sum of l_x and l_{x+1} by 2. On completing this column we will have a list of numbers some of whom lived ½ a year, some 1½ years, some 2½ years and so on.

If at any particular age we add up the numbers in the L_x column onwards until the end of the column, we then get the number of years lived by the number who started at the beginning of the year x, (l_x). This addition of $L_x + L_{x+1}$ and L_{x+2} up to the end of the table is called Q_x, and obviously Q_x divided by l_x gives the arithmetic mean of the different lengths of lives lived by the people composing l_x.

We therefore make a column Q_x where each term of the year is equal to the sum of the L_x column from that year onwards. Our final column is called e_x or the Expectation of Life at the year x on the definition given above, and is got for each year by dividing Q_x by l_x.

If the formation of L_x and Q_x columns is not clear, it will be so from a consideration of a small portion of a life table at its completed end. Our Life Table might be thus:—

Age x	l_x	L_x	Q_x	e_x
...	...	...	...	
90	847	654.5	1204.5	1.42
91	462	339	550	1.19
92	216	147.5	211	.98
93	79	50	63.5	.8
94	21	12	13.5	.64
95	3	1.5	1.5	.5

The three living at 95 die within the year. Their expectation of life is assumed to be half a year. The L_x column is $\frac{3+0}{2}=1.5$; and the Q_x column $1.5+0=1.5$ and the e_x column $=\frac{Q_x}{l_x}=\frac{1.5}{3}=\cdot 5$ year.

Of the 21 who were alive at age 94, 18 died within the year; they are assumed to have lived $\frac{1}{2}$ a year, therefore their total years of life was $18\times.5=9$. But three lived through the year and died next year; they lived $1\frac{1}{2}$ years and their lives together make $3\times1.5=4.5$ years. The 21 people therefore lived $9+4.5=13.5$ years; and their expectation of life $=\frac{13.5}{21}=.64$ year.

Notice the 13.5 obtained thus is the Q_x column obtained by adding the L_x column $=12+1.5=13.5$.

Similarly consider the 79 alive at 93

3	lived	$2\frac{1}{2}$ years	= 7.5 years
18	„	$1\frac{1}{2}$ years	=27.0 „
and 58	„	$\frac{1}{2}$ years	=29.0 „

A total of 63.5 years. And their expectation of life is $=\frac{63.5}{79}=.8$ year.

Here note again that the figure 63.5 obtained thus is the Q_x column obtained by adding the L_x column $50+12+1.5=63.5$.

The essential features of a life column would therefore be as follows :—

Age x	l_x	q_x	p_x	d_x	L_x	Q_x	e_x
0	1,00,000	.08996	.91004	8996	95502	5,562,000	55.62
1	91,004	.02339	.97661	2129	89939.5	5,466,610	60.07
2	88,875	.01050	.98950	933	88408.5	5,276,937	60.50
3	87,942	.00650	.99350	572	87656	5,288,831	60.14
4	87,370	.00475	.99525	415	87162.5	5,201,136	59.53
5	86,955	.00417	.99583	363	86773.5	5,113,783	58.81
6	86,592	.00337	.99663	292	86461	5,026,665	58.05
etc.	etc.	etc.	etc.	etc.	etc.	etc.	etc.

The expectation of life at any age is simply an average or arithmetic mean. It does not mean that any individual can 'expect' to live those numbers of years any more than any

individual would expect to earn the average salary of the people at his age.

Some other expressions are used, but are of little sanitary significance.

The "*probable duration*" of life or *equation of life* is the age at which half of our hypothetical number of persons will have died. It will be easily got from l_x column by noting the age at which this is 50,000. In England this age is about 60. In India about 10 years (*see* table page 598).

The *mean age at death* is at any one moment the sum of the ages of the people who die at that moment, divided by the number of persons dying. It is of no use as a contrasting test in different countries owing to the variations in birth-rates and migration.

The *mean after life time*, the *mean duration of life* and *vie moyenne* are synonyms for the *expectation of life*.

The expression the *most probable life time* is sometimes used to denote the *age* at which the greatest number of people die out in a life table population. It may be got by noting in the d_x table the year opposite which there is the highest number in the column. The first year of life is the highest in this respect in all communities; but neglecting this the 72nd year in England and the 38th year in India shows the highest number of deaths.

Expectation of Life at Births in Years

Country and date.	Males.	Females.
Australia, 1901-1910 ...	55.20	58.84
Denmark, 1906-1910	54.9	57.9
Norway, 1901-1910 .	54.84	57.72
Sweden, 1901-1910 ..	54.53	56.98
Holland, 1900-1909 ..	51.00	53.4
America, 1901-1910 ...	49.32	52.54
England, 1901-1910 ...	48.53	52.38
Switzerland, 1901-1910 .	49.25	52.15
France, 1898-1903 ...	45.74	49.13
Germany, 1901-1910 ...	44.82	48.33
Italy, 1901-1910 ...	44.24	44.83
Japan, 1898-1903 ...	43.97	44.85
India, 1901-1910 ...	22.59	23.31
Do 1921-1931 ...	26.91	26.56

Willich's Formula.—For English lives between 25 and 75, this gives approximately correct results.

If e = expectation of life

a = present age,

$$\text{then } e = \frac{2}{3}(80 - a)$$

Colonel Joubert, in comparing the expectancy of the Indian lives with those of Europeans, observes that though the constitutions of healthy Indians may not be much inferior to the European standard from a medical point of view, their habits, modes of life, and the insanitary conditions amidst which they live are most distinctly inferior to the European standard, and render them more liable to acute diseases increasing the risk of assurance. For Europeans and Anglo-Indians living in India the expectation of life as given in the following table has been calculated in some detail. Table A is based totally on Indian experience from European and Anglo-Indian lives, while Table B on Indian experience from European lives only up to the age of 80.

Age	Expectation A	Expectation B	Age	Expectation A	Expectation B
20		33.65	52	12.63	17.38
22	31.43	32.49	54	11.71	16.25
24	29.85	31.41	56	10.72	15.09
26	28.32	30.36	58	9.68	13.91
28	26.84	29.31	60	8.72	12.47
30	25.39	28.26	62	7.93	11.39
32	24.02	27.22	64	7.27	10 54
34	22.72	26.19	66	6.62	9.52
36	21.49	25 16	68	5.92	8.54
38	20.28	24.13	70	5.20	7.62
40	19.07	23.10	72	4.50	6.75
42	17.86	22.12	74	3.80	5.95
44	16.69	21.18	76	3.10	5.23
46	15.57	20.29	78	2.41	4.57
48	14.53	19.39	80	1.72	3.98
50	13.55	18.43			

Marriages.—These are usually stated in proportion to the total population, or the number per 1000 of population; but a more accurate method would be to base the marriage-rate for comparative purposes on the number of unmarried persons living at marriageable ages. With the Hindus marriage is an obligatory religious sacrament and is practially universal. The universality of marriage tends to produce a rapid increase of population. About half the total number of males are unmarried, and of these three-quarters are under 15 years of age. Only one-third of the total number of females are unmarried, and of these three-quarters are under the age of ten and seven-tenths of the remainder under fifteen.

In the following table the proportion of widows in the population per 1000 females and for certain age-periods

are given and compared with the figures for England and Wales :—

Age.	India 1931.	Age.	England and Wales 1911.
All ages	154.8	All ages	73.2
0-5	1.1	0-5	...
5-10	4.8	5-10	...
10-15	9.7	10-15	...
15-20	33.5	15-20	...
20-40	134.5	20-25	1.5
40-60	507.1	25-35	13.1
60 and ever	802.3	35-45	50.5
		45-65	193.3
		65 and over	566.9

The great difference between India and England in respect of marriage customs is shown by the fact that in England from three-fifths to two-thirds of both sexes are single and about a third are married. Three features are peculiar to India, *viz.*, universality of marriage, the early age of marriage, and the large proportion of widows.

There is probably a direct relation between early marriage and the duration of the reproductive functions, and the premature strain of the latter tends to their earlier cessation. Dr. Duncan found the average fecundity of women marrying at 15 to 19 years of age was 9.12, and it progressively diminished as age advanced, being 4.6 for those marrying at 30 to 34 years.

$$\frac{\text{Births}}{\text{Marriages}} = \text{mean of fecundity per marriage.}$$

The rapid succession of the generations, probably five or more in a century, is however, favourable to the process of adjustment to an environment that is subject to constant changes.

STATISTICAL METHODS

The training of the average medical man has not as a rule led him to take more than a very superficial interest in statistics and statistical methods of computation, but has rather led him to distrust statistics and those who make use of them. This is unfortunate. Not only does he miss something which helps to develop a true scientific attitude and to state facts and reason about them with precision and accuracy, but by the lack of such knowledge and attitude he is tempted to delude himself and others and to make grossly misleading statements based on insufficient or inaccurate premises. No attempt will be made to deal with the

subject exhaustively but merely to point out the necessity of some acquaintance with statistical methods. Those who wish to pursue the subject further are advised to read the books referred to in the end of the chapter.

We come across statements like the following in medical papers and books: "Of 1000 cases of cholera treated by ordinary method 500 die, the case mortality is 50 p.c. I treated 50 cases by a new method and only 20 died, the case mortality of 40 p.c. My method is therefore a great improvement on the ordinary method." Is this statement justified by the facts? Obviously the number of cases treated by the new method was not very large and one feels the evidence is not sufficient. Would the statement be justified if the number treated by the new method had been 100 and the deaths 40? Again, "The average pulse rate of 100 healthy people was 80 per minute. They were each given a dose of a new drug, the pulse rate was then 85; the new drug therefore quickens the pulse." Is this statement justified by the facts? We know by experience that if we take the average pulse rate of the same 100 healthy people on successive days, the average rate would not always be 80, but on some days it would be less and on other days higher. There would be a range of average pulse rates which would be due to *normal* daily changes or variations (or chance variations as they are called statistically); this range might be from 80 to 84 as determined by actual experiment. If our experimental pulse rate after giving the drug is within these limits, say 83, then the statement that the drug raised the pulse rate is of no value, but if it is outside the "natural limits of chance variations" then the statement has some truth, and the changed pulse rate is, as it is termed, *significant*. The purpose of statistical method is to determine these natural limits of variations and to enable the experimenter to judge the value or significance of any new experimental methods of treatment or pharmacological action.

Examples might be multiplied indefinitely, we give one more: "A community is examined month by month for hookworm infection. The degree of infection was measured by the average number of eggs per gram of fæces. The averages starting from January are 500, 480, 500, 500, 650, 750, 500, 480, 400, 450, 400, 450. The light infections were therefore found in the months of May and June, and the lowest in September and November." Obviously we cannot accept the statement as it stands. We must know the number examined, the proportion to the whole community, and the ordinary ranges of variations from these averages that might be expected as explained above. Statistical methods will show us how to determine these ranges and to see whether the different monthly averages fall within or without these ranges. If they are within, then they mean nothing special,

if they fall outside, then they are significant and special conclusions can be safely drawn, which may be of great importance both from a medical and public health point of view.

Averages :

It will be seen from this that an *average* is a very useful and convenient method of stating a group of observations, and it is constantly used. Death-rates, birth-rates, infantile mortality rates, case mortality rates, are all "averages" or "means". The arithmetical average is the one most commonly used. To find it the whole observations of quality (size, rate per minute, height, etc.) are added and divided by the number of observations. The height of boys at a particular age (say 10) may be taken.

Example 1 :—We go to a very small school in Bengal and pick out the boys aged ten. There are only six.

One is 40 inches in height
One „ 40 „ „ „
One „ 42 „ „ „
One „ 42 „ „ „
One „ 43 „ „ „
One „ 45 „ „ „
Total heights = 252 inches.

and the average height is $\frac{252}{6} = 42$ inches.

Is this a good average of the heights of Bengali boys of ten years of age? Obviously not, because the observations are on too small a number and four out of the six boys differ by as much as 2 inches from the average.

Example 2 :—Suppose we take 100 boys and we get the following results ;

1 is 35 inches in height	$1 \times 35 = 35$
1 is 36 „ „ „	$1 \times 36 = 36$
2 are 37 „ „ „	$2 \times 37 = 74$
4 are 38 „ „ „	$4 \times 38 = 152$
10 are 39 „ „ „	$10 \times 39 = 390$
20 are 40 „ „ „	$20 \times 40 = 800$
40 are 41 „ „ „	$40 \times 41 = 1640$
15 are 42 „ „ „	$15 \times 42 = 630$
5 are 43 „ „ „	$5 \times 43 = 215$
1 is 44 „ „ „	$1 \times 44 = 44$
1 is 45 „ „ „	$1 \times 45 = 45$
100	Total heights = 4061

We get the total combined heights of the 100 boys as shown on the right hand side of the table, by multiplying in each group by the number. The average height is therefore $4061 \div 100 = 40.61$ inches. This illustrates a "weighted average" where *weight* is given to the number in each group by multiplying the height of the group by the number in it. This average is obviously a better one than that of *example one* and we should get a *still* better average by taking 1000

boys. Statistically we say that the comparative values of averages vary as the square-root of the number of observations, in this instance as $\sqrt{6}$ to 100 or 2.7 is to 10; the second average is nearly 4 times better as an average than the first one.

Deviations :

If we take the 100 boys and put them in order at equal intervals along a wall we should get a picture like figure 158. This is called an "Array".

If we join the boys' heads we get a curve of a definite shape, flat in the middle and tailing off downards and upwards at each end. It is very often symmetrical about a line drawn half way along it. This line is called the "Median" (*see* LM, Fig. 158). If we place the mean we obtained by

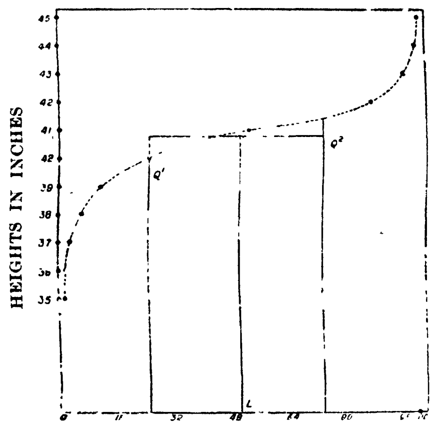

FIG. 158.—ARRAY : showing hundred boys arranged in order of their heights.

calculation 40.61 in. on the figure, it will be very nearly in this instance in the same position as the Median. If the curves are perfectly symmetrical, the median and the mean are identical. Is the median or the mean a fair average? The curve helps us to give an answer. If the curve is very flat in the centre, *i.e.*, if on either side there are grouped together a large number of individual boys who differ very little in height from the mean point (median) then there will be a very large proportion of the boys whose heights approximate to the average rate, and a very small proportion of boys who do not. In other words the mean will be a good one. We can judge of the "flatness" of the curve by going half way along from the centre and drawing a line up (*see* Q^1 and Q^2 in Fig. 158). These represent the heights half way between the median and the end points. These positions

are called *quartiles*. The flatter the curve, the less is the difference between LM and Q^1 and Q^2 and the better is the median a representation of the whole series; the greater the difference in length between the median and the quartile, the more does the curve fall away from the centre, and fewer of the boys approximate in height to the median and the median is then a much poorer representative of the whole series. Differences of any one item from the median (or mean) are called "deviations," and it is obvious that the deviation of the quartile from the median could be taken as the value of the mean, and the median could be written as $M \pm dQ$

where dQ is the deviation of the quartile from the mean;
and $M+dQ$ represents the upper quartile;
and $M-dQ$ the lower quartile.

There is no reason why this should not be done, but mathematicians have given us a better and more accurate method of measuring the value of a mean.

1. 2.	Deviation from mean 3.	Sums of deviation from mean 4.	Squares of deviation 5.	Sum of squares 6.
1 is 35	-5.61	5.61	31.4721	× 1 = 31.4721
1 „ 36	-4.61	4.61	21.2521	× 1 = 21.2521
2 are 37	-3.61	7.22	13.0321	× 2 = 26.0642
4 „ 38	-2.61	10.44	6.8121	× 4 = 27.2484
10 „ 39	-1.61	16.10	2.5921	× 10 = 25 9210
20 „ 40	-0.61	12.20	0.3721	× 20 = 77.4420
40 „ 41	+0.39	15.60	0.1521	× 40 = 6.0840
15 „ 42	+1.39	20 85	1.9321	× 15 = 28.9815
5 „ 43	+2.39	11.95	5.7121	× 5 = 28.5605
1 is 44	+3.39	3.39	11.4921	× 1 = 11.4921
1 „ 45	+4.39	4.39	19.2721	× 1 = 19.2721
100		123.36		233.7900

Arrange the series as in table and in column 3 place the deviations of each group from the mean (*e.g.*, $35-40.61=-5.61$ and in column 4 without regard to sign, put the product of the deviations and the number in each group; on summing column 4 we get the mean of all the deviations (123.36) and this divided by the total number of observations 100, gives 1.2336 or the "average deviation" of each item from the mean. The mean could then be be written 40.61 ± 1.2336 which means that $40.61+1.2336=41.8436$ represents the average deviations of items *above* the mean, and $40.61-1.2336=39.3764$ represents the average deviations of items *below* the mean. If we place these heights on Fig. 158 we could get positions approximating to the quartile.

Mathematicians, however, do not accept this "average deviation" as being correct enough as it does not give enough weight to the items which are farther away from the mean. They therefore adopt another deviation called the "*standard deviation*" designated by the symbol σ. First the deviations are squared and put in column 4. This squaring gives the additional "weight" to the items farthest from the mean. In column 5 are the products of these squares by the number in each group. The sum of the squares in column 5 is then divided by the number of observations (100) and the average "squared deviation" obtained. The square root of this is the "*standard deviation*" and is usually designated by the greek letter σ.

Thus in this instance the sum of the squares is 233.79; and therefore the standard deviation is $\sqrt{\frac{233.79}{100}} = \sqrt{2.3379}$ $=1.52$ inches.

It will be seen that the "standard deviation" is slightly higher than the "average deviation," as we would expect.

Frequency Curve:

Of what use is the standard deviation when we have got it? We may represent the information in *Example two* in another way by placing the heights along a base line and the number in each group as ordinates as shown in figure 159.

We get a bell shaped curvé which starts and ends near the base line. Our curve is not actually symmetrical because for one thing the observations are comparatively few. If the observations were very numerous we would find the curve

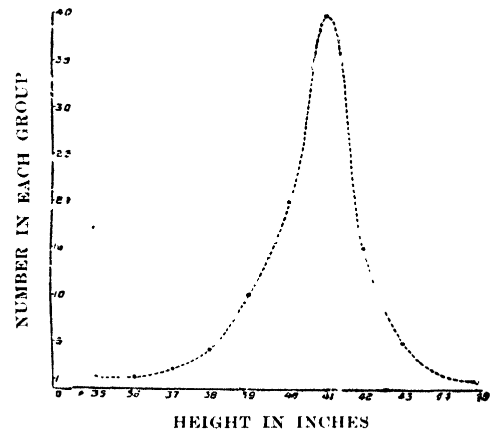

FIG. 159.—Frequency curve showing number of boys in each group of heights.

getting more and more symmetrical and of definite shape. We can get the same form of curve by tossing a dozen coins

a very large number of times and recording the number of heads (or tails) that turn up each time. The ideal curve obtained is called the "Normal Curve" and mathematically represents the chances or probabilities of certain events happening in an infinite or very large number of instances, when the chances of its happening are one out of two ways.

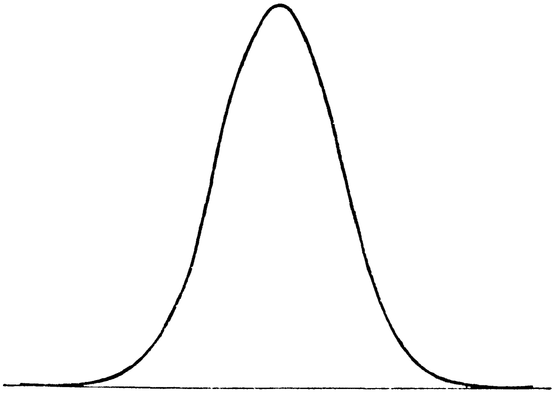

FIG. 160.—THE NORMAL CURVE.

This curve has definite mathematical properties, and it is on these properties that we base our treatment of standard deviations. Those properties must be accepted. If the student wishes to pursue the mathematical issues, he may study a special book on the subject.

The curve has the equation form $y=e^{-x^2}$
where e is the Napierian base of logarithms.

It is on the assumption that events happen in nature in conformity with this curve that we make use of this curve. This is an assumption of course, but it is found by experience to be a reasonable assumption. If we plot the heights or the weights of a large number of boys at a certain age, the specific gravities of a large number of milk samples, the size of walnuts, etc., etc., we find they all fit approximately to this curve.

If we plot out the number of items in Table 2 on page 618 as the deviations from the mean, we get a curve of the nature shown in figure 161. This is similar to the normal curve, and here again mathematicians assume that deviations occur in the same way in nature as ordinary happenings, that is, they follow the normal curve. That is, the maximum number of items which have no deviation from the mean is situated at 0, the number at each deviation on the *minus* side and on the *plus* side are symmetrically grouped about

the centre point of no deviation, and follow the line of the "Normal Curve."

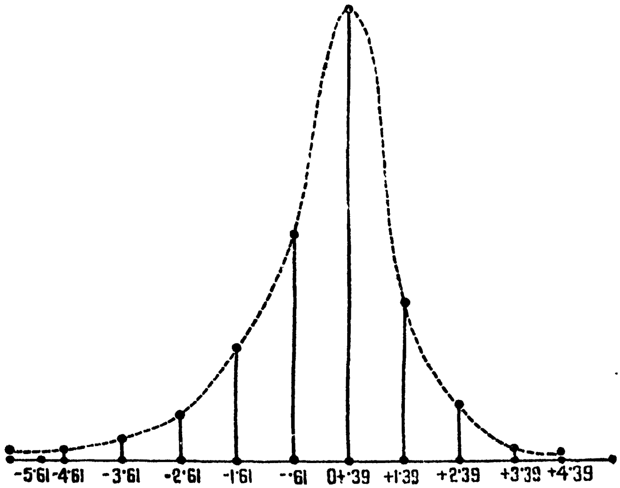

FIG. 161.—Frequency curve showing the numbers in each group of deviations from the mean.

If we agree to this we can proceed to make use of our "standard deviation." If we apply it to our normal curve of deviations it will fall into a certain place on the *plus* and

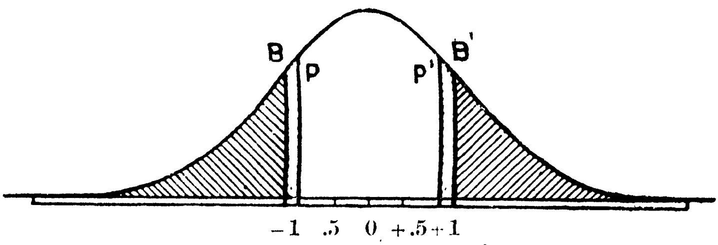

FIG. 162.—Curve of Deviations, Position of Standard Deviation and Probable Error. B and B′ show the Position of the Standard Deviation; P and P′ of the Probable Error. Note P and P′ are nearer 0 than B and B′. The distance of P and P′ from 0 is .6745 times the distance of B and B′ from 0. The area of the curve between P and P′ is equal to the sum of the crossed hatched area *plus* the areas between P and B and P′ and B′.

minus side of the 0 point (say B and B′), and the areas of the curve enclosed by B and B′ should represent Mean $+\sigma$ on one side and Mean $-\sigma$ on the other. This area should be approximately equal to the sum of the areas on the other sides of B and B′ (the shaded area). As a matter of fact the clear area is a little larger. Here a refinement comes in. If B and B′ are placed a little nearer to the centre at a

distance of 0.6745 times the distance from the centre, the areas will now be equal (the figure .6745 is obtained from the mathematical properties of the curve and we accept this without further argument). This new position of the standard deviation (.6745 times) is called the *most probable deviation* (or the *probable error*) because it represents a position of equal areas in the curve, where the chances of any particular deviation falling on one or other side of the probable error are equal. This deviation (probable error) is generally used instead of the standard deviation.

Take the curve of deviations again and put a line marking the positions of three times the probable error on each side

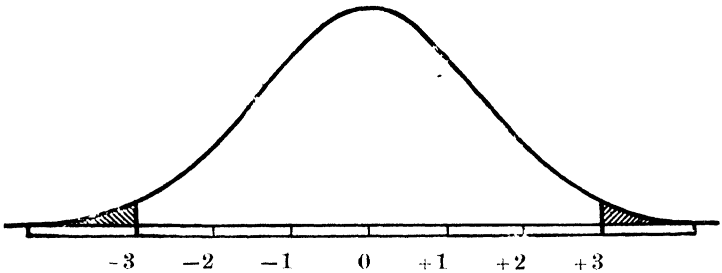

FIG. 163. The area of a normal curve inside (blank) and outside (shaded) the limits set by *three times the probable error*.

of the mean. (See fig. 163). It will be seen that this practically includes the whole of the deviations except for a very small number at the extreme ends of the *plus* and *minus* ends. The implication of this is very important and is a clue to understanding the whole application of the standard deviation or the "probable error."

If we take a range of Mean+3 times the probable error on one side and Mean − 3 times the probable error (written Mean±3 p.e.) this range will include all the likely numbers of the particular group under observation, and an individual picked at random from somewhere else, but supposed to belong to the same group (say boys of ten) would be likely to fall within these limits, otherwise there is something freakish, peculiar or significantly different about him.

To go back to the heights of boys of 10 years of age. We have found the mean to be 40.61±p.e. 0 6745×1.52 ; giving a range of 40.61+3×1.025=43.685 on one side and 40.61 − 3×1.025=37.535 on the other. These give a range of 43.7 to 37.5 inches approximately as likely to include all the possible heights of boys of ten of this class. Suppose we go into the street and pick any one boy of ten at random and find his height is 42.5 inches ; this fits into our range and we know that there is nothing specially significantly different so far as his height is concerned to our other boys. If his height

was outside our limits, say 45.5 inches, we would suspect that there was something essentially different in this boy from the class we have examined. He was either abnormally tall or abnormally short, or might belong to a different class of boys altogether, *e.g.*, a Punjabi.

If we took 100 boys in another town and found their *mean* (and not just *one individual*) and wished to compare this with the *mean* of our original lot of boys, it is obvious that our range should be more restricted than for the comparison of one individual only. In this case our standard deviation must be smaller and is found by dividing the standard deviation as found above by the square root of the number of observations, $\frac{1.52}{\sqrt{100}} = \frac{1.52}{10} = .152$. Our mean for this purpose would now be written 4 61$\pm$.152.

We could apply the above methods to the problem of hookworm infection (*see* page 616). We find first the mean of our observations of egg counts, say in 100 persons. We find the probable error of this mean, and multiply by 3; we then take a range of the mean *plus* three times the probable error, and the mean *minus* three times the probable error. Next month we repeat the observations and get a new mean for our egg counts, if this is within the limits as found above it is not significantly different from the mean of the previous month; if it is outside those limits, it is reasonable to suppose that the egg counts or the infection is significantly different from the previous month's, being either more or less as the case may be. This is a very important conclusion to be able to make, and without stating the probable error of the monthly means, the results might (though not necessarily) be quite valueless and the conclusions erroneous.

Coefficient of Variation:

The smaller the standard deviation or probable error in proportion to the mean, the more is the mean a good representation of the happenings; in other words the less variation there is of individual items from the mean. This may be expressed by dividing the standard deviation by the mean and expressing the result as a percentage, thus

$$\text{Coefficient of variation} = \frac{\sigma}{\text{mean}} \times 100.$$

The higher this is the greater the variability of the happenings. We might, for instance, compare the average rainfall in two different places for a series of years, and find the rainfall in place A to be 30$\pm$1.5 inches; in another B, 25$\pm$2.5 inches.

The coefficient of variations in the two places are respectively

$$\frac{1.5}{30} \times \frac{100}{1} = 5; \text{ and } \frac{2.5 \times 100}{25} = 10.$$

That is, the rainfall in B is more variable than in place A. In the same manner we are able to answer a question such as the following: "Is the length of the foot a more variable characteristic than say the size of the spleen?" This has been worked out and the coefficients of variations are 4.59 and 31.21 respectively, that is, the size of the spleen in man is more variable than the length of the foot.

The Probable error of Differences.—How do we apply the idea of the "*probable error*" to the question of the difference in the pulse rate noted at the beginning of this chapter? We do it as follows:—The probable error of the difference between two independent variables is equal to the square root of the sum of the squares of the probable errors of the quantities entering into the difference.

The following example will make it clear. The average pulse-rate per minute in a group of normal people was $79.68 \pm .15$ beats per minute. A drug was administered to all and the average pulse-rate then was $81.12 \pm .20$ beats per minute; (.15 and .20 being the probable errors). The difference is $81.12 - 79.68 = 1.44$; and the probable error of difference is $\sqrt{(.20)^2 + (.15)^2} = \sqrt{.04 + .0225} = \sqrt{.0625} = .25$. The difference is therefore $1.44 \pm .25$.

The difference is six times its probable error, and from our previous consideration of the normal curve, we conclude that the difference is *significant*, as three times the probable error is likely to include all differences due to chance or random sampling. In this case therefore we are justified in concluding that the drug had a real influence in quickening the pulse-rate and that the average quickening found was outside the limits likely to be due to chance variations of the pulse-rate in this group of people from day to day. In the above example probable errors and standard deviations have been used as synonymous, though strictly speaking the "probable errors" in the example should have been .6745 times the "standard deviations" given.

The use of the probable error in estimating the value of different treatments in diseases as measured by mortality.—Death-rates from individual diseases are usually expressed as "case mortality percentage." Take the following example, say cases of enteric treated by different methods, *viz.*, A, B and C.

	A	B	C	
No. of cases	1200	865	1236	
No. dying	42	20	10	
Case mortality	3.5	2.3	.81	per cent.

At first sight both B and C seem to be superior to A as methods of treatment. Is this really so, or are the differences in treatment possibly due to accidental sampling and

a small number of cases, and not really to the differences in treatment ?

Where we have a number of cases and when the results are only possibly two, *i.e.*, either dying or recovering then the following formula gives the probable error, based on the mathematics of the normal curve.

If n is the whole number of cases

and p the proportion of cases dying = $\left(\frac{\text{cases dying}}{\text{total cases}}\right)$

and q the proportion of cases recovering = $\left(\frac{\text{cases recovering}}{\text{total cases}}\right)$

then $p+q = 1$

and the probable error of p = $\pm .6745\sqrt{\frac{p\times q}{n}}$

$\sqrt{\frac{p\times q}{n}}$ being the standard deviation (σ).

For A the standard deviation $=\sqrt{\frac{p\times q}{n}}=\sqrt{\frac{3\cdot5\times96\cdot5}{1200}}$ per cent.

„ B „ „ „ $=\sqrt{\frac{2\cdot3\times97\cdot7}{865}}$ per cent.

„ C „ „ „ $=\sqrt{\frac{\cdot81\times99\cdot19}{1236}}$ per cent.

To compare series A with B.

The difference in case mortality is $3.5-2.3=1.2$ p.c.

The probable error of the difference (see above)

$$\sigma = .6745\sqrt{\text{sum of the squares of their standard deviations.}}$$

$$=.6745\sqrt{\left(\frac{\sqrt{3\cdot5\times96\cdot5}}{1200}\right)^2+\left(\frac{\sqrt{2\cdot3\times97\cdot7}}{865}\right)^2}$$

$$=.6745\sqrt{\left(\frac{3\cdot5\times96\cdot5}{1200}+\frac{2\cdot3\times97\cdot7}{865}\right)}\text{ per cent.}$$

$$= \cdot50 \text{ per cent}$$

The difference in case mortality between treatment A and treatment B may therefore be stated as $1.2\pm.5$ per cent.

The difference 1.2 is less than three times its probable error and therefore is not significant. There is therefore no real reason *on the evidence of case mortality alone*, that treatment B was superior to treatment A.

Comparing treatment A and treatment C.

The difference of mortality is $3.5-.81=2.69$ per cent.

The probable error of this difference is

$$=\cdot6745\sqrt{\frac{3\cdot5\times96\cdot5}{1200}+\frac{\cdot81\times99\cdot19}{1236}}\text{ per cent.}$$

$$=\cdot6745\sqrt{\cdot281+\cdot065}$$

$$=\cdot6745\sqrt{\cdot346}=\cdot4 \text{ per cent.}$$

$2.69\pm.4$ per cent. is the difference in mortality between A and C; 2.69 is greater than $(3\times.4)=1.2$ p.c.; therefore there

is justification for concluding that treatment C has really reduced the percentage mortality, other things being equal.

Correlation :

We constantly hear opinions expressed as follows : "The rains are unhealthy because most of the diarrhœa and dysentery occurs then." "The more the rainfall in any year the more the malaria, or the less the malaria." "Tall people have long arms" and so on. How can we judge of the truth or otherwise of these relationships. Galton and Pearson have given us a method of evaluating the relationship between two varying occurrences which appear to be independent of each other. The relationship is expressed as a number between -1 and $+1$. This is called the "Correlation Coefficient." If it is 0 there is no relationship at all. If -1, the relationship is apparently perfect but opposite, that is, as one variable increases, the other decreases proportionately. If $+1$, then the relationship is perfect in a positive manner. that is, as one variable increases or decreases the other increases or decreases proportionately. The following table shows the method of calculation. The standard deviations are first found, and then the products of individual deviations are multiplied and summed. This numerator is divided by the number of items in the series. The correlation coefficient is usually denoted by the symbol γ and the calculation to obtain it is as follows :—

$$\gamma = \frac{\Sigma\,(x \times y)}{N \times \sigma_1 \times \sigma_2}$$

Where x is the individual deviations of the first series ; and y the similar values of the second series. and Σxy the summation of the individual products of these. N = the number of observations, and σ_1 and σ_2 the respective standard deviations of the two series.

A simple example is given below :

Series 1.	x	x²	Series 2.	y	y²	x × y
1	−4	16	1	−6	36	+24
2	−3	9	4	−3	9	+ 9
3	−2	4	5	−2	4	+ 4
4	−1	1	6	−1	1	+ 1
5	0	0	8	+1	1	0
6	+1	1	10	+3	9	+ 3
7	+2	4	9	+2	4	+ 4
8	+3	9	8	+1	1	+ 3
9	+4	16	12	+5	25	+20
Mean = 5		$\Sigma x^2 = 60$	Mean = 7		$\Sigma y^2 = 90$	$\Sigma xy = +68$

If we look at the two series we note that there is a general tendency for the items of one to increase as the other

increases, but number 7 and 8 items in the series 2, diminish. We would therefore expect some positive (plus) correlation though not possibly a perfect one.

$$\sigma_1 = \sqrt{\frac{\Sigma x^2}{9}} = \sqrt{\frac{60}{9}} = 2{\cdot}58. \quad \sigma_2 = \sqrt{\frac{90}{9}} = \sqrt{10} = 3{\cdot}16$$

$\gamma = \dfrac{\Sigma xy}{N.\,\sigma_1\sigma_2} = \dfrac{68}{9 \times 2{\cdot}58 \times 3{\cdot}16} = +{\cdot}92$, which is a high positive correlation.

The probable error of the correlation coefficient is extremely important as a high coefficient might be based on a very small number of cases or merely be a chance distribution.

It is given by $\pm\ {\cdot}6745\ \dfrac{1-\gamma^2}{\sqrt{N}}$. In this case $.6745\ \dfrac{1-({\cdot}92)^2}{\sqrt{9}}$ $= \pm\ {\cdot}0512$.

The correlation coefficient is therefore $+.92 \pm$ p.e. $\cdot0512$. To be significant γ should be at least three times its p.e., but many statisticians say that it should be greater than six times.

It is much over that in this case, so that $+.92$ is a significant correlation. Correlations may therefore be high and significant, or high but not significant, or low and insignificant or low but significant.

REFERENCES: *Vital Statistics* by Whipple; *Medical Biometry and Statistics* by Raymond Pearl; *Vital Statistics* by Newsholme.

APPENDIX I

Indian Factories Act, 1934*

PRELIMINARY

2. In this Act, unless there is anything repugnant in the subject or context,—

(*a*) "adolescent" means a person who has completed his fifteenth but has not completed his seventeenth year:

(*b*) "adult" means a person who has completed his seventeenth year;

(*c*) "child" means a person who has not completed his fifteenth year;

(*d*) "day" means a period of twenty-four hours beginning at midnight;

(*e*) "week" means a period of seven days beginning at midnight on Saturday night;

(*g*) "manufacturing process" means any process—

(*i*) for making, altering, repairing, ornamenting, finishing or packing, or otherwise treating any article or substance with a view to its use, sale, transport, delivery or disposal, or

(*ii*) for pumping oil, water or sewage, or

(*iii*) for generating, transforming or transmitting power;

(*h*) "worker" means a person employed, whether for wages or not, in any manufacturing process, or in cleaning any part of the machinery or premises used for a manufacturing process, or in any other kind of work whatsoever incidental to or connected with the manufacturing process or connected with the subject of the manufacturing process, but does not include any person solely employed in a clerical capacity in any room or place where no manufacturing process is being carried on;

(*j*) "factory" means any premises including the precincts thereof whereon twenty or more workers are working, or were working on any day of the preceeding twelve months, and in any part of which a manufacturing process is being carried on with the aid of power or is ordinarily so carried on.

5. (*1*) Notwithstanding anything contained in clause (*j*) of section 2, the Local Government may, by notification in the local official Gazette, declare any premises whereon or within the precincts whereof a manufacturing process is carried on, whether with or without the aid of power, and whereon or within the precincts whereof, on any one day of the twelve months preceeding the notification, ten or more workers were employed, to be a factory for all or any of the purposes of this Act.

THE INSPECTING STAFF

10. (*1*) The Local Government may, by notification in the local official Gazette, appoint such persons as it thinks fit to be Inspectors for the purposes of this Act within such local limits as it may assign to them respectively.

(2) The Local Government may, by notification as aforesaid, appoint any person to be a Chief Inspector, who shall, in addition to the powers conferred on a Chief Inspector under this Act, exercise the powers of an Inspector throughout the province.

* This should replace the Indian Factories Act, 1911, given on page 107.

(*3*) No person shall be appointed to be an Inspector under sub-section (*1*) or a Chief Inspector under sub-section (*2*) or, having been so appointed, shall continue to hold office, who is or becomes directly or indirectly interested in a factory or in any process or business carried on therein or in any patent or machinery connected therewith.

(*4*) Every District Magistrate shall be an Inspector for his district.

(*5*) The Local Government may also, by notification as aforesaid, appoint such public officers as it thinks fit to be additional Inspector for all or any of the purposes of this Act, within such local limits as it may assign to them respectively.

(*6*) In any area where there are more Inspectors than one, the Local Government may, by notification as aforesaid, declare the powers which such Inspectors shall respectively exercise, and the Inspector to whom the prescribed notices are to be sent.

(*7*) Every Chief Inspector and Inspector shall be deemed to be a public servant within the meaning of the Indian Penal Code and shall be officially subordinate to such authority as the Local Government may specify in this behalf.

11. Subject to any rules made by the Local Government in this behalf, an Inspector may, within the local limits for which he is appointed,—

(*a*) enter, with such assistants (if any), being persons in the employment of Government or of any municipal or other public authority, as he thinks fit, any place which is, or which he has reason to believe to be, used as a factory or capable of being declared to be a factory under the provisions of section 5 ;

(*b*) make such examination of the premises and plant and of any prescribed registers, and take on the spot or otherwise such evidence of any persons as he may deem necessary for carrying out the purposes of this Act; and

(*c*) exercise such other powers as may be necessary for carrying out the purposes of this Act;

Provided that no one shall be required under this section to answer any question or give any evidence tending to criminate himself.

12. (*1*) The Local Government may appoint such registered medical practitioners as it thinks fit to be certifying surgeons for the purposes of this Act within such local limits as it may assign to them respectively.

(*2*) A certifying surgeon may authorise any registered medical practitioner to exercise any of his powers under this Act :

Provided that a certificate of fitness for employment granted by such authorised practitioner shall be valid for a period of three months only, unless it is confirmed by the certifying surgeon himself after examination of the person concerned.

Health and Safety

13. Every factory shall be kept clean and free from effluvia arising from any drain, privy or other nuisance, and shall be cleansed at such times and by such methods as may be prescribed, and these methods may include lime-washing or colour-washing, painting, varnishing, disinfecting and deodorising.

14. (*1*) Every factory shall be ventilated in accordance with such standards and by such methods as may be prescribed.

(*2*) where gas, dust or other impurity is generated in the course of work, adequate measures shall be taken to prevent injury to the health of workers.

(*3*) If it appears to the Inspector that in any factory gas, dust or other impurity generated in the course of work is being inhaled by the workers to an injurious extent, and that such generation or inhalation could be prevented by the use of mechanical or other devices, he may serve on the manager of the factory an order in writing, directing that mechanical or other devices for preventing

such generation or inhalation shall be provided before a specified date, and shall thereafter be maintained in good order and used throughout working hours.

(*4*) The Local Government may make rules for any class of factories requiring mechanical or other devices to be provided and maintained for preventing the generation or inhalation of gas, dust or other impurities, which may be injurious to workers and specifying the nature of such devices.

15. (*1*) The Local Government may make rules—

(*a*) prescribing standards for the cooling properties of the air in factories in which the humidity of the air is artificially increased :

(*b*) regulating the methods used for artificially increasing the humidity of the air; and

(*c*) directing prescribed tests for determining the humidity and cooling properties of the air to be carried out and recorded.

(*2*) If any factory in which the humidity of the air is artificially increased, the water used for the purpose shall be taken from a public supply or other source of drinking water, or shall be effectively purified before it is so used.

(*3*) If it appears to the Inspector that the water used in a factory for increasing humidity which is required to be effectively purified under sub-section (*2*) is not effectively purified, he may serve on the manager of the factory an order in writing, specifying the measures which in his opinion should be adopted, and requiring them to be carried out before a specified date.

16. If it appears to the Chief Inspector or to an Inspector specially authorised in this behalf by the local Government that the cooling properties of the air in any factory are at times insufficient to secure workers against injury to health or against serious discomfort, and that they can be to a great extent increased by measures which will not involve an amount of expense which is unreasonable in the circumstances, the Chief Inspector may serve on the manager of the factory an order in writing, specifying the measures which in his opinion should be adopted, and requiring them to be carried out before a specified date.

17. In order that no room in a factory shall be crowded during working hours to a dangerous extent or to an extent which may be injurious to the health of the workers, the proportion which the number of cubic feet of space in a room and the number of superficial feet of its floor area bears to the number of workers working at any time therein shall not be less than such standards as may be prescribed either generally or for the particular class of work carried on in the room.

18. (*1*) A factory shall be sufficiently lighted during all working hours.

(*2*) If it appears to the Inspector that any factory is not sufficiently lighted, he may serve on the manager of the factory an order in writing° specifying the measures which in his opinion should be adopted, and requiring them to be carried out before a specified date.

(*3*) The Local Government may make rules requiring that all factories of specified classes shall be lighted in accordance with prescribed standards.

19. (*1*) In every factory a sufficient supply of water fit for drinking shall be provided for the workers at suitable places.

(*2*) The supply required by sub-section (*1*) shall comply with such standards as may be prescribed.

(*3*) In every factory in which any process involving contact by the workers with injurious or obnoxious substances is carried on, a sufficient supply of water suitable for washing shall be provided for the use of workers, at suitable places and with facilities for its use, according to such standards as may be prescribed.

20. For every factory sufficient latrines and urinals, according

to the prescribed standards, shall be provided, for male workers, and for female workers separately, of suitable patterns and at convenient places as prescribed, and shall be kept in a clean and sanitary condition during all working hours.

21. In every factory the doors of each room in which more than twenty persons are employed shall, except in the case of sliding doors, be constructed so as to open outwards, or, where the door is between two rooms, in the direction of the nearest exit from the building, and no such door shall be locked or obstructed while any work is being carried on in the room.

22. In every factory such precautions against fire shall be taken as may be prescribed.

23. *(1)* Every factory shall be provided with such means of escape in case of fire as can reasonably be required in the circumstances of each factory.

(2) If it appears to the Inspector that any factory is not so provided, he may serve on the manager of the factory an order in writing, specifying the measures which in his opinion should be adopted, and requiring them to be carried out before a specified date.

(3) The means of escape shall not be obstructed while any work is being carried on in the factory.

24. *(1)* In every factory the following shall be kept adequately fenced, namely :—

(a) every exposed moving part of a prime mover and every flywheel directly connected to a prime mover.

(b) every hoist or lift, hoist-well or lift-well, and every trap-door or similar opening near which any person may have to work or pass, and

(c) every part of the machinery which the Local Government may prescribe.

(2) If it appears to the Inspector that any other part of the machinery in a factory is dangerous if not adequately fenced, he may serve on the manager of the factory an order in writing, specifying the measures which in his opinion should be adopted, and requiring them to be carried out before a specified date.

(3) All fencing required by or under this section or under subsection *(1)* of section 26 shall be maintained in an efficient state at all times when the workers have access to the parts required to be fenced except where they are under repair or are under examination in connection with repair or are necessarily exposed for the purpose of cleaning or lubricating or altering the gearing or arrangements of the machinery.

(4) Such further provisions as may be prescribed shall be made for the protection from danger of persons employed in attending to the machinery in a factory.

25. If it appears to the Inspector that any building or part of a building, or any part of the ways, machinery or plant in a factory is in such a condition that it may be dangerous to human life or safety, he may serve on the manager of the factory an order in writing requiring him before a specified date—

(a) to furnish such drawings, specifications and other particulars as may be necessary to determine whether such building, ways, machinery or plant can be used with safety, or

(b) to carry out such tests as may be necessary to determine the strength or quality of any specified parts and to inform the Inspector of the results thereof.

26. *(1)* If it appears to the Inspector that any building or part of a building, or any part of the ways, machinery or plant in a factory is in such a condition that it is dangerous to human life or safety, he may serve on the manager of the factory an order in writing specifying the measures which in his opinion should be adopted, and requiring them to be carried out before a specified date.

(2) If it appears to the Inspector that the use of any building or part of a building or of any part of the ways, machinery or plant in a factory involves imminent danger to human life or safety, he may serve on the manager of the factory an order in writing prohibiting its use until it has been properly repaired or altered.

27. (*1*) No woman or child shall be allowed to clean or oil any part of the machinery of a factory while that part is in motion under power, or to work between moving parts or between fixed and moving parts of any machinery which is in motion under power.

(*2*) The Local Government may, by notification in the local official Gazette, prohibit, in any specified factory or class of factories, the cleaning or oiling by any person of specified parts of machinery when these parts are in motion under power.

28. (*1*) The Local Government may make rules prohibiting the admission to any specified class of factories, or to specified parts thereof, of children who cannot be lawfully employed therein.

(*2*) If it appears to the Inspector that the presence in any factory or part of a factory of children who cannot be lawfully employed therein may be dangerous to them or injurious to their health, he may serve on the manager of the factory an order in writing directing him to prevent the admission of such children to the factory or any part of it.

29. No woman or child shall be employed in any part of a factory for pressing cotton in which a cotton-opener is at work:

Provided that, if the feed-end of a cotton-opener is in a room separated from the delivery end by a partition extending to the roof, or to such height as the Inspector may in any particular case specify in writing, women and children may be employed on the side of the partition where the feed-end is situated.

30. Where in any factory an accident occurs which causes death, or which causes any bodily injury whereby any person injured is prevented from resuming his work in the factory during the forty-eight hours after the accident occurred, or which is of any nature which may be prescribed in this behalf, the manager of the factory shall send notice thereof to such authorities, and in such form and within such time, as may be prescribed.

33. (*1*) The Local Government may make rules requiring that in any specified factory, wherein more than one hundred and fifty workers are ordinarily employed, an adequate shelter shall be provided for use of workers during periods of rest, and such rules may prescribe the standards of such shelters.

(*2*) The Local Government may also make rules—

(*a*) requiring that in any specified factory, wherein more than fifty women workers are ordinarily employed, a suitable room shall be reserved for the use of children under the age of six years belonging to such women, and

(*4*) Where the Governor General in Council is satisfied that any operation in a factory exposes any person employed upon it to a serious risk of bodily injury, poisoning or disease, he may make rules applicable to any factory or class of factories in which the operation is carried on

(*a*) specifying the operation and declaring it to be hazardous,

(*b*) prohibiting or restricting the employment of women, adolescents or children upon the operation,

(*c*) providing for the medical examination of persons employed or seeking to be employed upon the operation and prohibiting the employment of persons not certified as fit for such employment, and

(*d*) providing for the protection of all persons employed upon the operation or in the vicinity of the places where it is carried on.

Restrictions on Working Hours of Adults

34. No adult worker shall be allowed to work in a factory for

more than fifty-four hours in any week, or, where the factory is a seasonal one, for more than sixty hours in any week:

Provided that an adult worker in a non-seasonal factory engaged in work which for technical reasons must be continuous throughout the day may work for fifty-six hours in any week.

35. (1) No adult worker shall be allowed to work in a factory on a Sunday unless—

(*a*) he has had or will have a holiday for a whole day on one of the three days immediately before or after that Sunday, and

(*b*) the manager of the factory has, before that Sunday or the substituted day, whichever is earlier,—

(*i*) delivered a notice to the office of the Inspector of his intention to require the worker to work on the Sunday and of the day which is to be substituted, and

(*ii*) displayed a notice to that effect in the factory;

Provided that no substitution shall be made which will result in any worker working for more than ten days consecutively without a holiday for a whole day.

(3) Where, in accordance with the provision of sub-section (1), any worker works on a Sunday and has had a holiday on one of the three days immediately before it, that Sunday shall, for the purpose of calculating his weekly hours of work, be included in the preceding week.

36. No adult worker shall be allowed to work in a factory for more than ten hours in any day;

Provided that a male adult worker in a seasonal factory may work for eleven hours in any day.

37. The periods of work of adult workers in a factory during each day shall be fixed either—

(*a*) so that no period shall exceed six hours, and so that no worker shall work for more than six hours before he has had an interval for rest of at least one hour;

(*b*) so that no period shall exceed five hours and so that no worker shall work for more than five hours before he has had an interval for rest of at least half an hour, or for more than eight and a half hours before he has had at least two such intervals.

38. The periods of work of an adult worker in a factory shall be so arranged that along with his intervals for rest under section 37, they shall not spread over more than thirteen hours in any day, save with the permission of the Local Government and subject to such conditions as it may impose, either generally or in the case of any particular factory.

45. (1) The provisions of this Chapter shall, in their application to women workers in factories, be supplemented by the following further restrictions, namely:—

(*a*) no exemption from the provisions of section 36 may be granted in respect of any woman; and

(*b*) no women shall be allowed to work in a factory except between 6 A.M. and 7 P.M.

Provided that the Local Government may, by notification in the local official Gazette, in respect of any class or classes of factories and for the whole year or any part of it, vary the limits laid down in clause (*b*) to any span of thirteen hours between 5 A.M. and 7 P.M.

Provided further that, in respect of any seasonal factory or class of seasonal factories in a specified area, the Local Government may make rules imposing a further restriction by defining the period or periods of the day within which women may be allowed to work, such that the period or periods so defined shall lie within the span fixed by clause (*b*) or under the above proviso and shall not be less than ten hours in the aggregate.

(2) The Local Government may make rules providing for the exemption from the above restrictions, to such extent and subject to

such conditions as it may prescribe, of women working in fish-curing or fish-canning factories where the employment of women beyond the said hours is necessary to prevent damage to or deterioration in any raw material.

(3) Rules made under sub-section (2) shall remain in force for not more than three years.

46. Where a worker works on a shift which extends over midnight, the ensuing day for him shall be deemed to be the period of twenty-four hours beginning when such shift ends, and the hours he has worked after midnight shall be counted towards the previous day.

Provided that the Local Government may, by order in writing, direct that in the case of any specified factory or any specified class of workers therein the ensuing day shall be deemed to be the period of twenty-four hours beginning when such shift begins and that the hours worked before midnight shall be counted towards the ensuing day.

48. No adult worker shall be allowed to work in any factory on any day on which he has already been working in any other factory, save in such circumstances as may be prescribed.

Special Provision for Adolescents and Children

50. No child who has not completed his twelfth year shall be allowed to work in any factory.

51. No child who has completed his twelfth year and no adolescent shall be allowed to work in any factory unless—

(*a*) a certificate of fitness granted to him under section 52 is in the custody of the manager of the factory, and

(*b*) he carries while he is at work a token giving a reference to such certificate.

52. (1) A certifying surgeon shall, on the application of any young person who wishes to work in a factory, or of the parent or guardian of such person, or of the manager of the factory in which such person wishes to work, examine such person and ascertain his fitness for such work.

(2) The certifying surgeon, after examination, may grant to such person, in the prescribed form,—

(*a*) a certificate of fitness to work in a factory as a child, if he is satisfied that such person has completed his twelfth year, that he has attained the prescribed physical standards (if any), and that he is fit for such work; or

(*b*) a certificate of fitness to work in a factory as an adult, if he is satisfied that such person has completed his fifteenth year and is fit for a full day's work in a factory.

(3) A certifying surgeon may revoke any certificate granted under sub-section (2) if, in his opinion, the holder of it is no longer fit to work in the capacity stated therein in a factory.

(4) Where a certifying surgeon or a practitioner authorised under sub-section (2) of section 12 refuses to grant a certificate or a certificate of the kind requested, or revokes a certificate, he shall, if so requested by any person who could have applied for the certificate, state his reasons in writing for so doing.

53. (1) An adolescent who has been granted a certificate of fitness to work in a factory as an adult, under clause (*b*) of sub-section (2) of section 52, and who, while at work in a factory, carries a token giving reference to the certificate shall be deemed to be an adult for all the purposes.

(2) An adolescent who has not been granted a certificate of fitness to work in a factory as an adult under sub-section (2) of section 52, shall, notwithstanding his age, be deemed to be a child for the purposes of this act.

54. (1) No child shall be allowed to work in a factory for more than five hours in any day.

(2) The hours of work of a child shall be so arranged that they shall not spread over more than seven-and-a-half hours in any day.

(3) No child shall be allowed to work in a factory except between 6 A.M. and 7 P.M.:

Provided that the Local Government may, by notification in the local official Gazette, in respect of any class or classes of factories and for the whole year or any part of it, vary these limits to any span of thirteen hours between 5 A.M. and 7-30 P.M.

(4) The provisions of section 35 shall apply also to child workers but no exemption from the provisions of that section may be granted in respect of any child.

(5) No child shall be allowed to work in any factory on any day on which he has already been working in another factory.

55. (1) There shall be displayed and correctly maintained in every factory, in accordance with the provisions of sub-section (2) of section 76, a Notice of Periods for Work for Children, showing clearly the periods within which children may be required to work.

(2) The periods shown in the Notice required by sub-section (1) shall be fixed beforehand in accordance with the method laid down for adults in section 39 and shall be such that children working for those periods would not be working in contravention of section 54.

(3) The provisions of section 40 shall apply also to the Notice of Periods for Work for Children.

(4) The Local Government may make rules prescribing forms for the Notice of Periods for Work for Children and the manner in which it shall be maintained.

56. (1) The manager of every factory in which children are employed shall maintain a Register of Child Workers showing

(*a*) the name of each child worker in the factory,

(*b*) the nature of his work,

(*c*) the group, if any, in which he is included,

(*d*) where his group works on shifts, the relay to which he is allotted,

(*e*) the number of his certificate of fitness granted under section 52, and

(*f*) such other particulars as may be prescribed.

(2) The Local Government may make rules prescribing the form of the Register of Child Workers, the manner in which it shall be maintained, and the period for which it shall be preserved.

57. No child shall be allowed to work otherwise than in accordance with the Notice of Periods for Work for Children displayed under sub-section (*1*) of section 55 and the entries made beforehand against his name in the Register of Child Workers maintained under sub-section (*1*) of section 56.

58. Where an Inspector is of opinion—

(*a*) that any person working in a factory without a certificate of fitness is a child or an adolescent, or

(*b*) that a child or adolescent working in a factory with a certificate is no longer fit to work in the capacity stated therein,

he may serve on the manager of the factory a notice requiring that such person, or that such child or adolescent, as the case may be, shall be examined by a certifying surgeon or by a practitioner authorised under sub-section (2) of section 12, and such person, child or adolescent shall not, if the Inspector so directs, be allowed to work in any factory until he has been so examined and has been granted a certificate of fitness or a fresh certificate of fitness, as the case may be.

59. The Local Government may make rules—

(*a*) prescribing the forms of certificates of fitness to be granted under section 52, providing for the grant of duplicates in the event of loss of the original certificates, and fixing the fees which may be charged for such certificates and such duplicates;

(*b*) prescribing the physical standards to be attained by children and adolescents;

(*c*) regulating the procedure of certifying surgeons under this Chapter, and specifying other duties which they may be required to perform in connection with the employment of children and adolescents in factories; and

(*d*) providing for any other matter which may be expedient in order to give effect to the provisions of this Chapter.

APPENDIX II

Instructions for District Health Officers in Bengal

1. The District Health Officer shall communicate to the Health Officer of a municipality situated within the district any information which he may possess as to any danger to health threatening that municipality.

2. He shall see that the subordinate public health staff are diligent in searching for omission in the register of births, and as far as possible, that careful watch is kept at burial-grounds and burning ghats to ensure that bodies are properly disposed of and that every death is duly recorded.

3. In consultation with the Chairman he shall arrange for the delivery at important *melas*, fairs, religious festivals and agricultural exhibitions of simple lectures on sanitation and the prevention of disease, illustrated, if possible, by magic lantern slides. With the permission of the Chairman and of the local educational authorities, he may also deliver lantern lectures on sanitation and the prevention of disease in such schools as he may from time to time visit.

4. Whenever necessary or advisable, or whenever directed to do so by competent authority, he shall inspect the sanitary condition of railway stations and steamer ghats in his district, reporting the result of his inspection to the District Board, the District Magistrate and the Director of Public Health simultaneously.

5. Every Monday he shall forward to the Director of Public Health by post, at such an hour as in the ordinary course of post will ensure its delivery to the Director of Public Health on the following Tuesday morning a return, in such form as the Government or the Director of Public Health may from time to time require, showing the number of cases of infectious disease notified to him during the week ending on the preceding Saturday night. He shall also forward at the same time duplicate copies of the return to the District Magistrate and to the Health Officer or Officers of any municipality or municipalities in his district.

6. He shall transmit to the Director of Public Health, the District Magistrate and the municipality or municipalities in his district copies of his annual report and of any special report.

(*Bengal Government, Municipal Department Circular, No 367-71 San., dated the 2nd July, 1920*).

APPENDIX III

The Duties, etc., of District Health Officers in Bengal

In addition to the duties imposed upon him by any law, for the time being in force, regarding public health, every District Health Officer shall perform the following duties:—

(1) He shall perform all the duties imposed upon him by properly constituted bye-laws and regulations of the District Board in respect of any matter affecting public health.

(2) He shall attend the meetings of the Sanitation Committee of the District Board.

(3) He shall execute and enforce the regulations, rules and orders, relating to public health, which may be enacted, made or issued by competent authority.

(4) He shall keep himself informed, as far as practicable, respecting all influences affecting or threatening to affect injuriously the public health in the district. For this purpose, he shall visit the several areas or localities under his jurisdiction, as occasion may require.

(5) He shall inquire into and ascertain the causes, origin, and distribution of diseases within the district, and ascertain to what extent the same depend on conditions capable of removal or mitigation.

(6) He shall consult with the Health Officers of municipalities within his district whenever the circumstances may render this desirable.

(7) He shall advise the District Board on all matters affecting the health of the district and on all sanitary points involved in the action of the Board; and, in cases requiring it, he shall certify, for the guidance of the District Boards, as to any matter in respect of which the certificate of a Medical Officer of Health is required as the basis or in aid of sanitary action.

(8) He shall, from time to time, inquire into and report upon the accommodation available in hospitals or dispensaries either maintained or aided by the District Board for the isolation of cases occurring in the district of (*a*) cholera, (*b*) small-pox, (*c*) plague, and (*d*) other infectious diseases, and upon any need for the provision of further accommodation.

(9) On receiving information of the outbreak of any infectious or epidemic disease of a dangerous character within the district, he shall visit without delay the locality where the outbreak has occurred, and inquire into the causes and circumstances of such outbreak; and in case he is not satisfied that all due precautions are being taken, he shall advise the persons competent to act as to the measures which appear to him to be required to prevent the extension of the disease, and shall take such measures for the prevention of disease as he is legally authorized to take under any law in force in the district or by any resolution of the District Board.

(10) Subject to the instructions of the District Board, he shall direct or superintend the work of subordinate public health staff of the district, and on receiving information that his intervention is required in consequence of the existence of any nuisance injurious to public health, he shall, as early as practicable, take such steps as he is legally authorized to take.

(11) He shall pay particular attention to the water-supply of the district, especially if it is derived from public wells or reserved tanks. He shall report to the Chairman if the public wells are not kept in good repair and if the reserved tanks are not properly fenced and kept free from contamination, and he shall render every assistance to ensure the purity of the water-supply.

(12) In order to facilitate the adoption of measures for reducing the prevalence of malarial fever, he shall have a careful survey made of the distribution of malaria in the district. When, as a result of his survey, he has obtained an accurate knowledge of the distribution and relative intensity of the malaria existing in different parts of the district, he shall prepare a detailed scheme of antimalarial sanitation designed to meet the existing conditions, and shall submit it to the Chairman of the District Board for the approval and sanction of the Board.

(13) He shall see that vaccination is carried out thoroughly and efficiently by the subordinate public health staff of the District Board. In the course of his tours of inspection, he shall carefully ascertain, in the case of every village inspected, the proportion of children protected and those not protected by vaccination, and shall report the same to the Chairman.

(14) He shall arrange for the attendance, either of himself or of members of the subordinate public health staff, at important *melas*, fairs, religious festivals and agricultural exhibitions in the District Board area, and for the erection of temporary latrine accommodation and the protection of the water-supply, in order to guard against the occurrence of water-borne disease.

(15) If he is of opinion that any trade or occupation or the keeping of any goods or merchandise, by reason of its being injurious to the public health, should be suppressed or removed or prohibited or that action should be taken regarding any public nuisance, he shall report the matter to the Chairman, so that action may be taken under section 133 of the Code of Criminal Procedure, 1898, or any other provision of law.

(16) He shall, from time to time, but not less than once every month, report in writing to the District Board his proceedings and the measures which may require to be adopted for the improvement or protection of the public health in the district. He shall in like manner report with respect to the sickness and mortality within the district, so far as he has been able to ascertain the same.

(17) He shall forthwith report to the Director of Public Health any case of plague, cholera, or small-pox, or any serious outbreak of epidemic disease in the district which may be notified to him or which may otherwise come or be brought to his knowledge.

(18) He shall, as soon as practicable, after the 31st day of December in each year make in a form prescribed by competent authority, an annual report to the District Board up to the end of December, on the sanitary circumstances and the sanitary administration of the district.

(19) At least a month before the date for the preparation and consideration of the annual budget of the District Board, he shall submit a programme of the sanitary works and improvement which he proposes for execution during the following year.

2. Every District Health Officer is entitled to draw travelling allowance in accordance with the rules for the purpose in the Civil Service Regulations for journeys performed on duty.

3. Every District Health Officer is entitled to the benefit of the leave rules under the Civil Service Regulations, should there be no separate approved set of leave rules prescribed by the District Board under which he is employed.

4. The appointment, removal and dismissal of every District Health Officer is subject to the approval of the Commissioner of the Division in which the district is included.

5. Every District Health Officer shall be directly under the orders and control of the Chairman of the District Board.

6. The subordinate public health staff of a District Board will be under the immediate order and control of the District Health Officer.

(*Bengal Government, Municipal Department Circular*, No. 25-29T.—*San., dated the* 9th *June* 1920.)

APPENDIX IV

The Duties of Sanitary Inspectors

1. (1) *Control of Conservancy Department.*—The principal duty of Sanitary Inspectors is to see that the Conservancy Department does its work properly. They must therefore divide their time between the various branches of that department.

(2) Sanitary Inspectors must particularly bear in mind that it is their business not merely to order work to be done but to see that it is actually carried out.

2. (1) *Inspection.*—The Sanitary Inspector must commence his inspection at an early hour in the morning when the actual cleaning operations are in progress. When passing round his ward or town, he must see that the scavengers are at work, and that the rubbish is being properly removed and that the road drains are cleaned.

(2) He must visit all public latrines and urinals and a large number of private privies and cess-pools. In this connection, he must arrange to meet the *jamadar* of the private latrines, conservancy department, daily and receive his report as to whether any complaints have been made and whether the department is working satisfactorily.

(3) He must not consider that his duties indicated in sub-rules (1) and (2) are complete until he has seen the street rubbish properly removed and the night-soil from the public latrines carried away to the trenching-ground.

(4) He must keep a note-book in such form as the Chairman of the Municipality may prescribe, in which he shall record the particulars of such defects in private privies or latrines as require action by the owners and of the action taken to remove them.

(5) In the course of his round, he must—

(*a*) take note of any useless undergrowth and tanks that require clearance, and report the same to the Medical Officer of Health [*Chairman of the Municipality*]* and

(*b*) check the muster-rolls of the *methars* and menials

3. (1) *Conservancy, animals and property.*—He must pay particular attention to the condition of the conservancy animals, seeing that the *gowkhana* is kept clean, that the bullocks are properly fed, and that all their minor ailments are treated at once.

(2) If serious diseases, such as rinderpest and anthrax, appear in the *gowkhana*, he must take every possible precaution and must, without delay, obtain the help of the veterinary assistant, if one is available.

(3) He must also see that the conservancy carts, night-soil buckets and other tools and plant of the Conservancy Department are kept clean and in proper order.

4. (1) *Markets.*—In the course of his round, the Sanitary Inspector must inspect all markets, buildings, shops, stalls or places used for the sale or storage of articles intended for food.

(2) If he finds in any market, building, shop, stall or place used for the sale or storage of articles intended for food, or as a slaughter-house, any articles which appear to be unfit for food, he must seize them and report the matter at once to the Medical Officer of Health [*Chairman of the Municipality*],* who will thereupon take suitable action under the Bengal Municipal Act, 1932.

4A. (1) He shall make regular inspections of cowsheds and dairies and report whether they are in sanitary condition. He shall also see that the milk-vessels kept for such cowsheds or dairies are properly cleansed and sterilised.

(2) If when making any such inspection or at any other time he detects any contagious or infectious disease amongst milch-cattle, especially tubercular diseases of the udder, he shall report the fact to the Health Officer [*Chairman of the Municipality*]* and shall take such precautions as may be necessary.

5. *Trenching-grounds.*—He must visit each trenching-ground at least three times a week, and must see that all sewage is properly buried there:

Provided that this rule shall not apply in towns where there is a special Sanitary Inspector deputed to be in sole charge of this part of the conservancy work.

6. (1) *Births and deaths.*—In the course of his inspection, the Sanitary Inspector must take note of all births and deaths that he may hear of, and must report them to the Municipal Registrar.

(2) He must also visit burning ghats and burial grounds once a week, if any exist within his ward or town, and enquire into the number of bodies disposed of there since his last visit.

7. *Epidemic diseases.*—He must at once report to the Medical Officer of Health [*the Civil Surgeon or the Chairman of the Municipality*]* the outbreak of epidemic diseases, such as cholera, small-pox and plague, or any suspicious increase in the mortality or sickness of his ward or town.

8. (1) *Prevention of encroachments on road or drains, and pollution of water-supply.*—He must bring to the notice of the Medical Officer of Health [*the Chairman of the Municipality*]* any encroachment on to any road or any illegal covering up of the municipal drains.

(2) He must also report to the same officer the insanitary condition of any well or tank, any defects in the water-hydrants and the name of any person who wastes the public water-supply.

(3) He must inspect all sources of public water-supply and take steps to prevent pollution of the water and the spread of water-borne disease by calling the attention of the Medical Officer of Health [*the Chairman*]* to any case in which it appears necessary to take action under section 309 of the Bengal Municipal Act, 1932.

9. *Slaughter-houses.*—He must inspect all slaughter-houses from time to time, and must see that they are kept in a clean and sanitary condition, and that all refuse is removed therefrom to the trenching-ground.

10. *Daily report.*—In the afternoon of each working day, he must go to the office of the Medical Officer of Health [*the Chairman*]* to make his report and to receive any orders that may be given to him.

He must also report any instance of a public nuisance within the municipality which requires immediate removal for the sake of public health and safety.

11. *Hostels and sarais.*—He must, from time to time, inspect all hostels and *sarais* within the municipal area.

12. *Knowledge of certain provisions relating to the public health.*—He must be thoroughly conversant with all sections of the Bengal Municipal Act, 1932, which relate to the public health.

*The words in italics within square brackets should be substituted for "the Medical Officer of Health" in municipalites in which there is no such officer.

(*Circulars Nos.*—2072-76M., *dated the* 29th *October* 1915, *and No.* 8 *San., dated the* 28*th February* 1917, *by the Government of Bengal, Municipal Department*).

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